Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

DECEMBER, 1955

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TECHNOLOGY DEPT.

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BLAW-KNOX

The linking together of these two great names in the metal-producing industry offers you their combined engineering abilities, production facilities and craftsmanship in the designing and the construction of rolling mill equipment. It's your assurance of even better service in the production of both ferrous and non-ferrous metals.

CONTINENTAL
Foundry & Machine
Company

BLAW-KNOX COMPANY

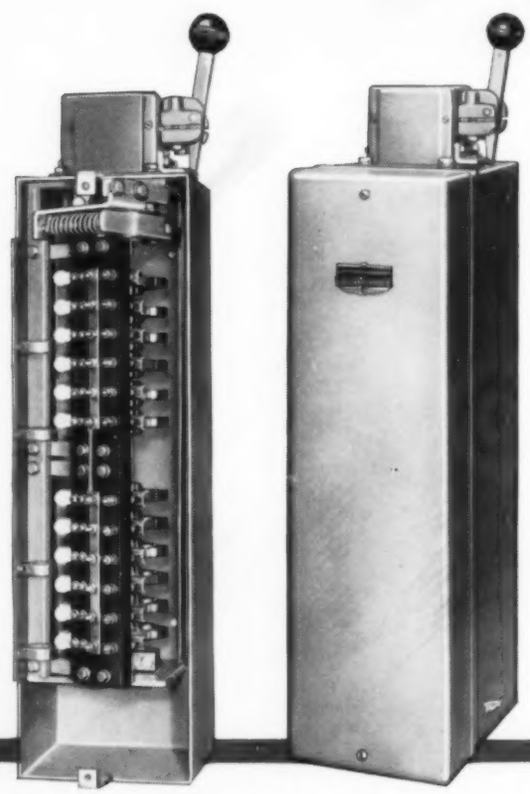
Farmers Bank Building
Pittsburgh 22, Pa.

NOW— the "THIN" MASTER

for crowded cab and pulpit space

The new Cutler-Hammer Bulletin 14951 Type D Cam Master Switch measures only 7⅝ inches wide. It's designed especially for crane cab or mill pulpit use where space is at a premium. 4 of them will fit in 30 inches, all within easy reach of the operator. You can have this new master switch with bevel gear type handle which can easily be set in any one of 4 positions 90° apart. Or with radial type operating handle. Operating handle "feel" or tension is easily adjustable. Off position latch is optional. Spring return easily available. All adjustments made in field. You can have it in 6, 12, or 16 circuits. Overall case length, 16, 25¼ and 30" respectively. A maximum of 6 speed points in either direction. Available as open type for benchboard mounting, or enclosed type for base mounting.

All parts of this new master are easily and completely accessible for wiring, installation and inspection. Simply remove cover—there's ample wiring space about the terminal board. A wire way is provided on left side of terminal board. Contact fingers and cams can be removed individually—easily and quickly. This entirely new switch employs basic principles of design and construction tested and proved over many years of service in the metal working and allied industries. Save space. Save installation and wiring costs. Save operator fatigue. Get better, more dependable operation. Order bulletin 14951 *now*. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



Easy to install, wire and inspect

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

ANOTHER *expansion* FOR AETNA-STANDARD

● Aetna-Standard's fourth major expansion in 15 years expands production capacity by 40%.

The expansion increases machining, welding and assembly facilities with more floor space and new machine tools. A new power plant moves the KVA load from 300 to 750 KVA capacity.

The continued demand for steel, copper, brass, aluminum, rubber and plastic requires more and more production machinery, such as Aetna-Standard designs and manufactures. Capacity to produce more equipment is a **responsibility** of the machinery manufacturer who depends upon these basic industries for his orders.

AETNA • STANDARD

THE AETNA-STANDARD ENGINEERING COMPANY

GENERAL OFFICES: PITTSBURGH, PA. **PLANTS: ELLWOOD CITY, PA., WARREN, OHIO**

CONTINUOUS GALVANIZING LINES • CONTINUOUS ELECTROLYTIC TINNING LINES • SIDE TRIMMING AND SHEAR LINES AND OTHER FINISHING EQUIPMENT • CONTINUOUS BUTT WELD PIPE MILLS • SEAMLESS TUBE MILLS • DRAWBENCHES AND OTHER COLD DRAW EQUIPMENT • ROLLS AND CASTINGS • EXTRUDERS, MILLS, PRESSES FOR RUBBER AND PLASTIC

big industry, small world

annealing covers
billet reheating furnaces, continuous
carbon restoration and annealing furnaces, continuous
controlled atmosphere generators
high-speed stress relieving furnaces
one-way fired soaking pits
pit-type annealing furnaces
slab and billet heaters, continuous
strip annealing furnaces, continuous
strip galvanizing lines, continuous
wire patenting furnaces, continuous

Wherever this steel goes – from first soak to final shipping dock – it will find that the big steel industry is a small world as far as 'Surface' equipment is concerned. Somewhere along the line, whatever its destined shape, the steel will be made more workable and more useful in 'Surface' furnaces.

Why is it so easy to bump into 'Surface' in steel mills? One reason is that 'Surface' has literally grown up with the steel industry. A better reason is the confidence that steelmakers have in the performance of furnaces and generators manufactured by Surface Combustion Corp., Toledo 1, Ohio.

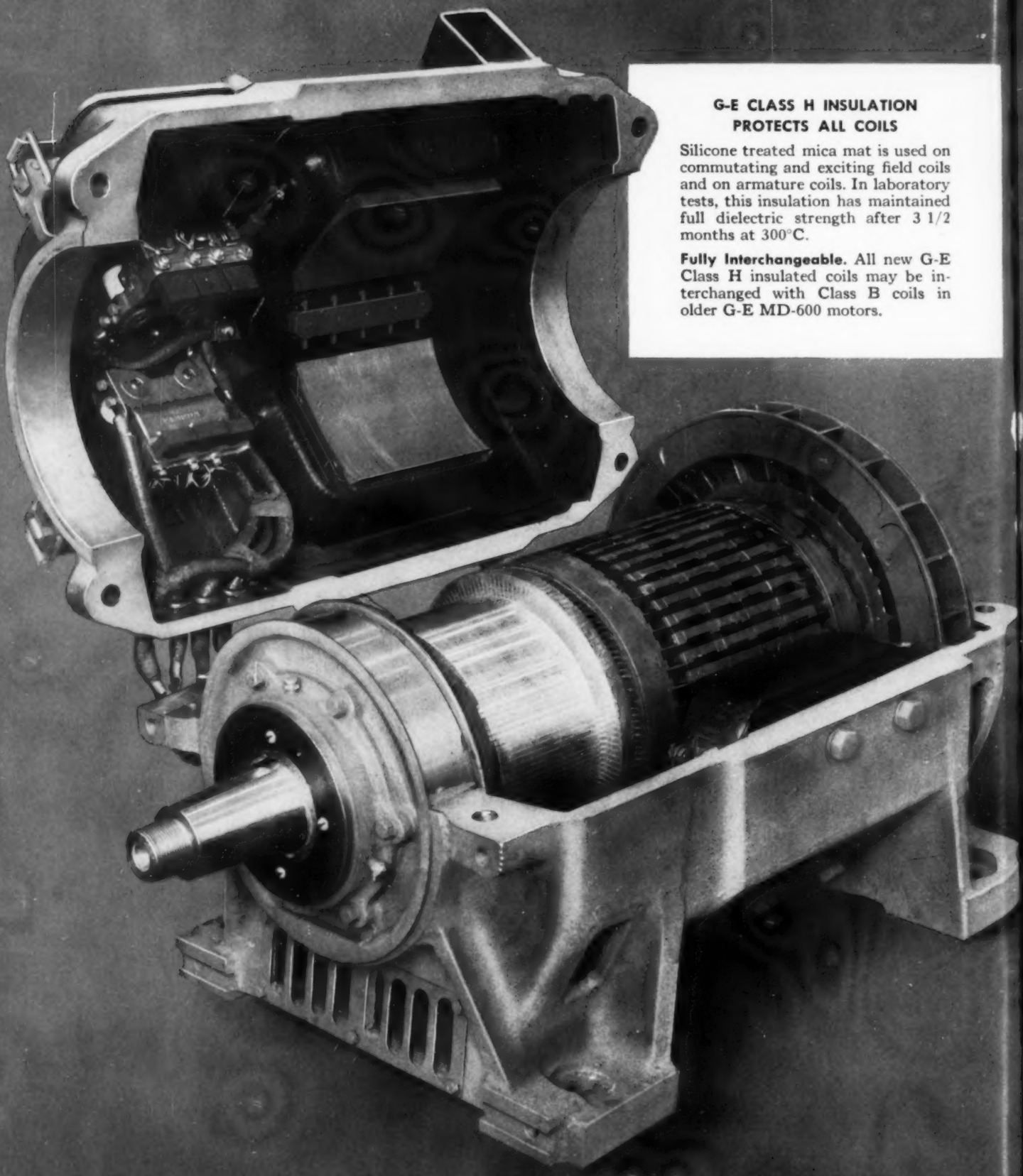
Surface
STEEL MILL FURNACES

British Furnaces, Ltd., Chesterfield; Stein & Atkinson, Ltd., London
Stein & Roubaix, Paris, Leige, and Genoa; Chugai Ro Kogyo Kaisha, Ltd., Osaka
Benno Schilde Maschinenbau, G.m.b.H., Bad Hersfeld (Hessen, Germany)

PROGRESS IN
DIRECT-CURRENT DRIVES

NOW! Roastouts

NEW G-E MD-600 MOTORS



G-E CLASS H INSULATION PROTECTS ALL COILS

Silicone treated mica mat is used on commutating and exciting field coils and on armature coils. In laboratory tests, this insulation has maintained full dielectric strength after 3 1/2 months at 300°C.

Fully Interchangeable. All new G-E Class H insulated coils may be interchanged with Class B coils in older G-E MD-600 motors.

Virtually Eliminated on . . .

WITH CLASS H INSULATION

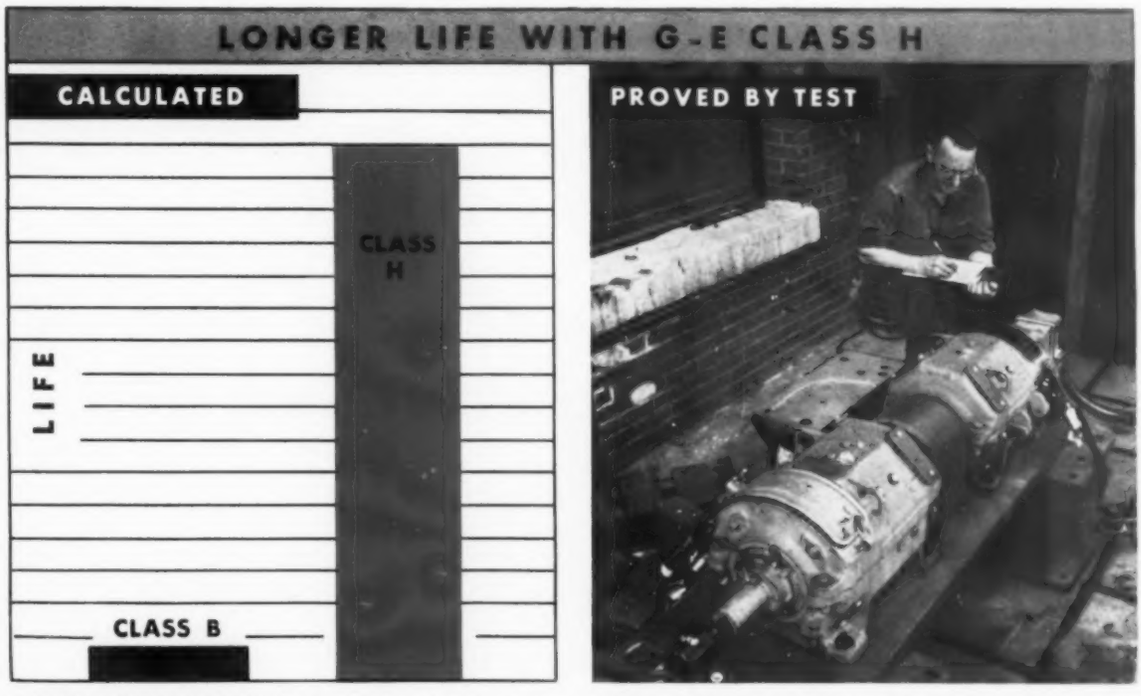
G.E. offers—in all MD-600's—Class H Insulated Coils

WHAT IS CLASS H? General Electric research has developed a combination of inorganic and silicone materials for a new insulation system now used in all MD-600 motors. These Class H materials will withstand temperatures up to 180°C continuously.

BETTER FOR HEAVY DUTY. Auxiliary mill motors often encounter unexpected high ambient temperatures, unforeseen extended duty or emergency conditions. Any one of these can cause "roastouts" from temperatures higher than the insulation capacity. The new G-E Class H insulation will resist up to 50°C more than Class B, resulting in longer motor service.

REWINDS ELIMINATED? On normal duty, insulation failure may be eliminated as the limiting factor in continuous armored motor service. Engineers calculate that each 10°C rise in temperature reduces the life of a given type of insulation by half. *Since G-E Class H will withstand 50°C higher than Class B, its life* **at the same temperature** *should be increased 2^5 or 32 times!*

YOUR G-E SALES REPRESENTATIVE HAS COMPLETE INFORMATION. Contact him at your nearby G-E Apparatus Sales Office, or write Section 812-1, Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.

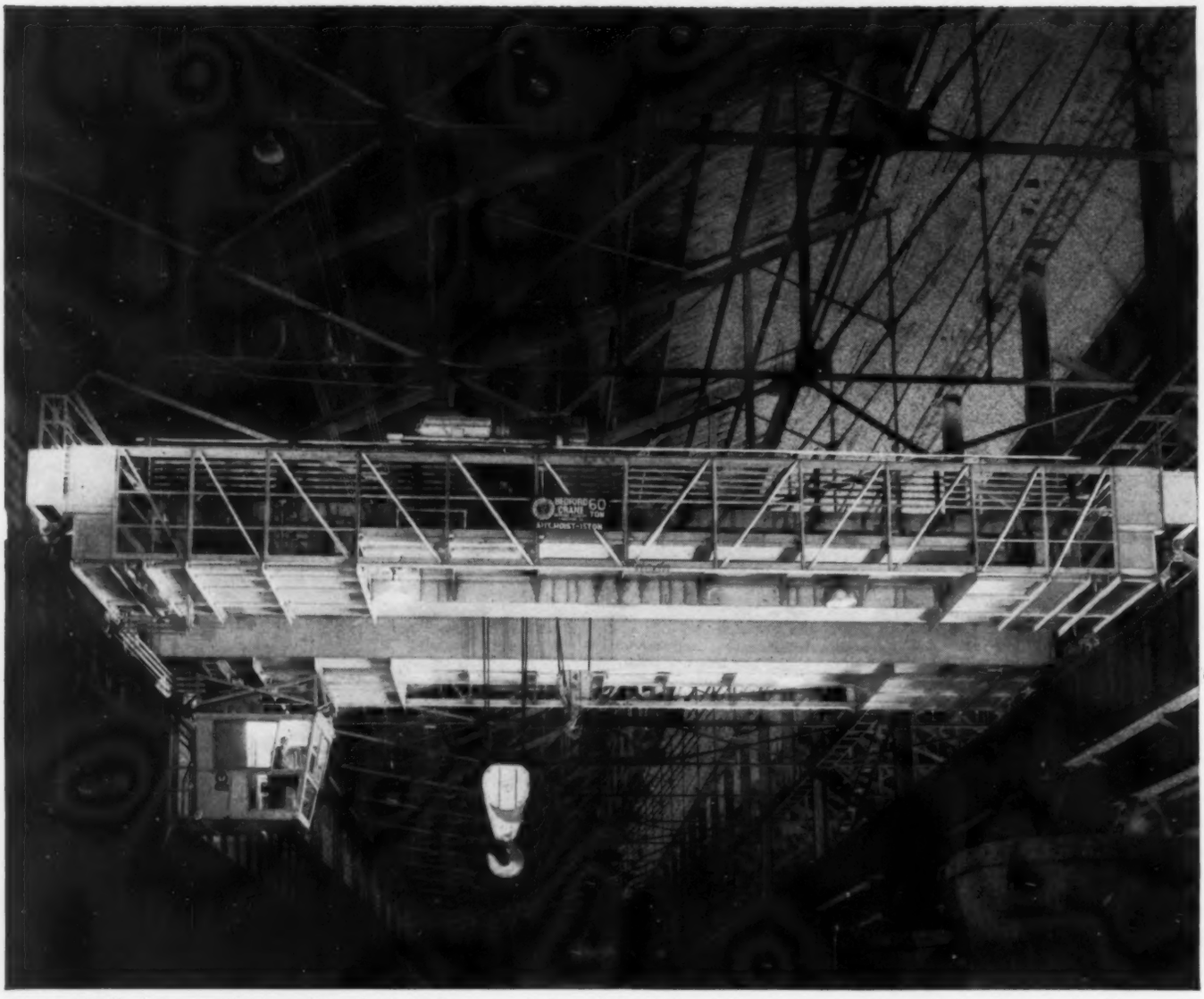


ENGINEERING STUDIES indicate that under identical operating conditions new G-E Class H insulated coils in MD-600 motors will last up to *32 times* as long as conventional Class B coils. Insulation failure may be eliminated as the limiting factor in continuous auxiliary mill motor service.

ACTUAL TEST with Class H and Class B motors coupled together *proves to date* the new insulation will last more than twice as long as the old. After burning out two Class B insulated motors, the one with Class H coils is still operating under exaggerated load, vibration and atmospheric conditions.

Progress Is Our Most Important Product

GENERAL ELECTRIC



Sixty-ton Bedford Crane with air-conditioned cab in the new melt shop of The Timken Roller Bearing Co., Canton, Ohio. Working directly over the severe flash heat of top charging electric furnaces, it positions and dumps approximately 40 tons of scrap per swing.

Bedford Cranes are backed by 52 years of specialized experience

Proof of the superiority of Bedford Cranes is found in the high percentage of *repeat orders* from important owners through the years.

In steel mills, power plants, and throughout industry . . . wherever superior performance is *expected,* owners enthusiastically recommend Bedford Cranes.

Available in all types and sizes . . . from five tons to 350 tons and up . . . for all kinds of indoor and outdoor services . . . each Bedford Crane is individually engineered and precision built for its specific application.

Built to the most modern standards and backed by more than 50 years of specialized crane building *and utilization* experience . . . Bedford Cranes have won fame the world over for advanced design and for safe, smooth, dependable performance.

You are invited to consult a Bedford Engineer on your next crane problem . . . with all the facts on the table, we believe you too will make *your* next crane a Bedford.

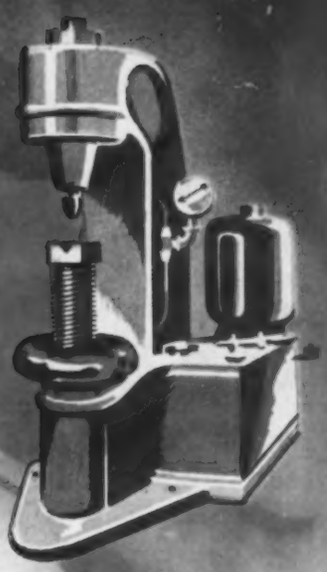
(Write for complete catalog describing Bedford Cranes in detail.)

STEEL MILL CRANES BEDFORD

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

Uniformity!

THE CONTROL OF
EVERY SQUARE INCH
OF EVERY COIL



UNIFORMITY — that's the big reason why so many of the leading steel producers are specifying Annealing Furnaces by Lee Wilson. The exclusive method by which Wilson furnaces apply the heat to the charge enables users to get exacting control of every inch of every coil. It's precision annealing in its most advanced stage. Look them over — talk with users and you'll be convinced there's nothing that approaches the speed and uniformity of the Lee Wilson furnace. And why not? It's a product of the originator and leading producer of radiant tube, single-stack annealing systems.
FOR YOUR FILES: *Brochures and data sheets that give you the complete story.*

Lee Wilson ENGINEERING COMPANY, INC.
20005 West Lake Road, Cleveland 16, Ohio

Frequent Instrument Check-ups Prevent Emergencies

The economical way to protect your plant's investment in instrumentation is a Honeywell Periodic Service Plan. Under this plan, a Honeywell service specialist comes to your plant at regular intervals to—

— Check your Brown instruments and calibrate them against accurate laboratory standards.

— Inspect all moving parts, clean and lubricate them, and replace where necessary.

You get this kind of service performed regularly for your office equipment such as typewriters and calculating machines . . . for your automobile . . . and even for yourself by periodic check-ups by your doctor. You've learned that the ounce of prevention is a good investment. Well, the same philosophy applies to instruments, too. Keeping them in good condition is far more economical than waiting for emergencies to throw production schedules into a tailspin.

Here, briefly, is what the Honeywell Periodic Service Plan does. It provides you—

Periodic examination and adjustment by a factory-trained service engineer.

Automatic attention. Calls are made on a schedule that fits your own plant's requirements . . . at a cost substantially lower than an equivalent emergency service call.

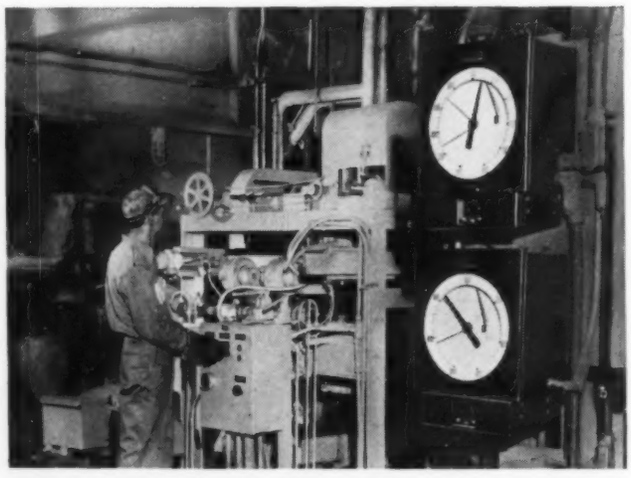
Continuous operation. Good instruments kept in top condition can be counted on for steady duty, without costly shut-downs. Well-maintained instruments last longer, too.

Increased plant efficiency. Greater reliability of operation builds confidence of plant personnel in their equipment.

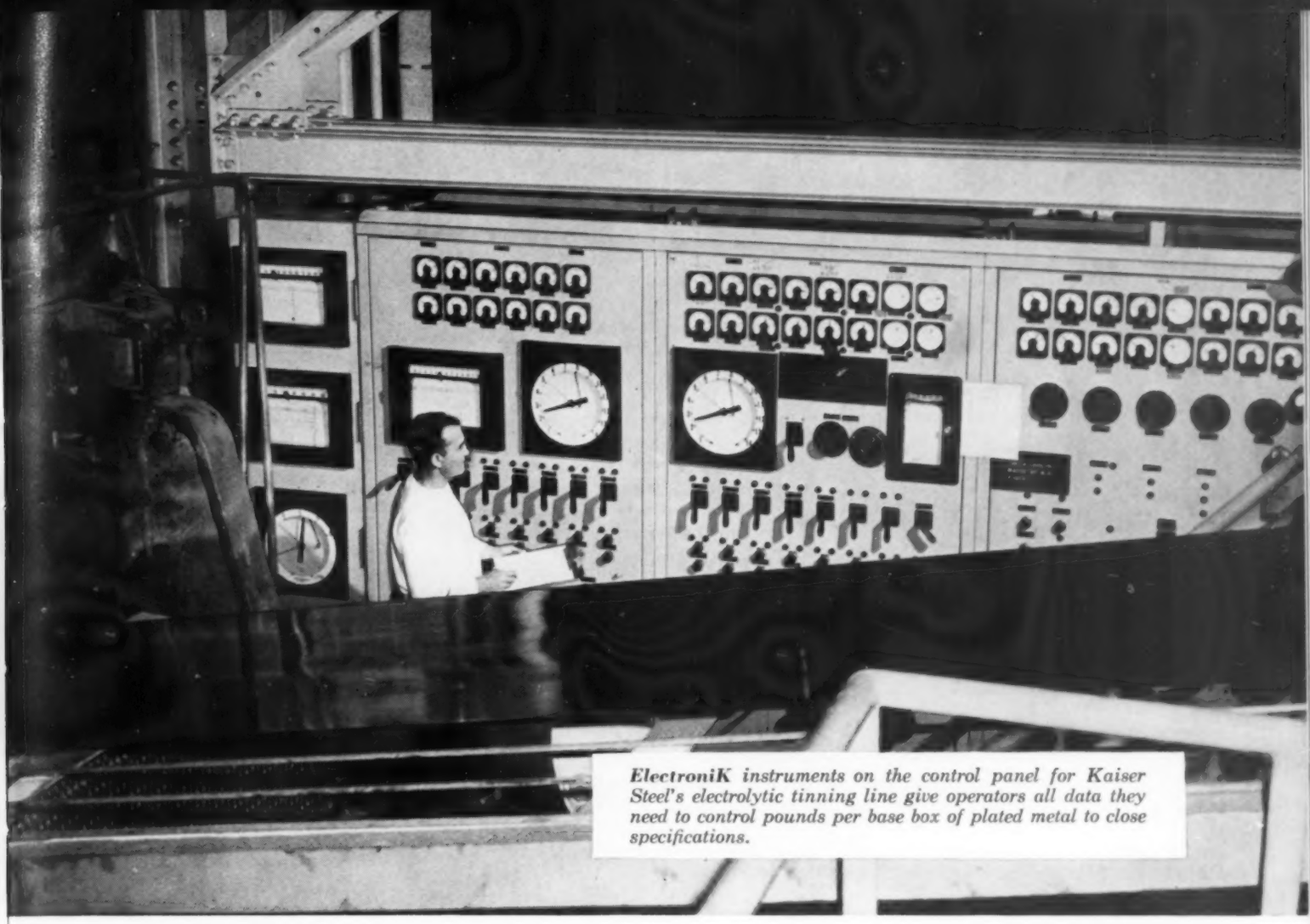
At any time, of course, you can count on prompt emergency service from any one of the more than 100 Honeywell service centers spotted throughout the United States and Canada.

The Plan is extremely simple. It costs remarkably little, and can pay real dividends in protection of your production schedules and your instrument investment. For details about how it can be applied to your own plant, call your local Honeywell office.

Kaiser Steel's tinning lines hold high quality and economy . . .



On control panel for hot dip tinning process are ***ElectroniK*** *instruments for regulating temperatures of dip metal and oil bath.*



ElectroniK instruments on the control panel for Kaiser Steel's electrolytic tinning line give operators all data they need to control pounds per base box of plated metal to close specifications.

with *ElectroniK* controls

KEEPING high-capacity production equipment operating at peak economy—while maintaining high standards of quality—is an assignment where modern Honeywell instrumentation proves a profitable investment. On tinning operations at Kaiser Steel's Fontana Mill, for example, Brown controls are helping to improve quality and uniformity of plated products.

For the electrolytic tinning line, designed by The Wean Engineering Company, control was engineered by General Electric and R&S Equipment Company. The central instrument panel concentrates complete data on the process for the line operators. At a glance, they can note critical plating currents, coating distribution and top and bottom pounds per base box . . . all recorded in detail on *ElectroniK* instruments. This information guides operators in holding weight of plating to exact specifications . . . reducing rejects . . . and achieving maximum utilization of electric power and plating materials.

On the hot dip tinning installation, also designed by Wean, temperatures are held within close limits by *ElectroniK* instruments with *Electr-O-Line* proportioning control. Accurate temperatures of the molten metal bath make it possible to control the thickness of tin coatings and to avoid waste of metal. Improved quality and smoother surfaces on finished plate result from precise control of oil bath temperatures.

Throughout the steel industry, Brown instruments have proved their ability to aid in making better products more economically. A complete line of instrumentation, developed and applied by men who know the needs of steel production, is ready to serve you. For a discussion of your specific requirements, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Catalog No. 1521, "*ElectroniK* Recorders" . . . and No. 1531, "*ElectroniK* Controllers"

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

TIMKEN® bearings on the axles take shock loads of 110-ton ore car

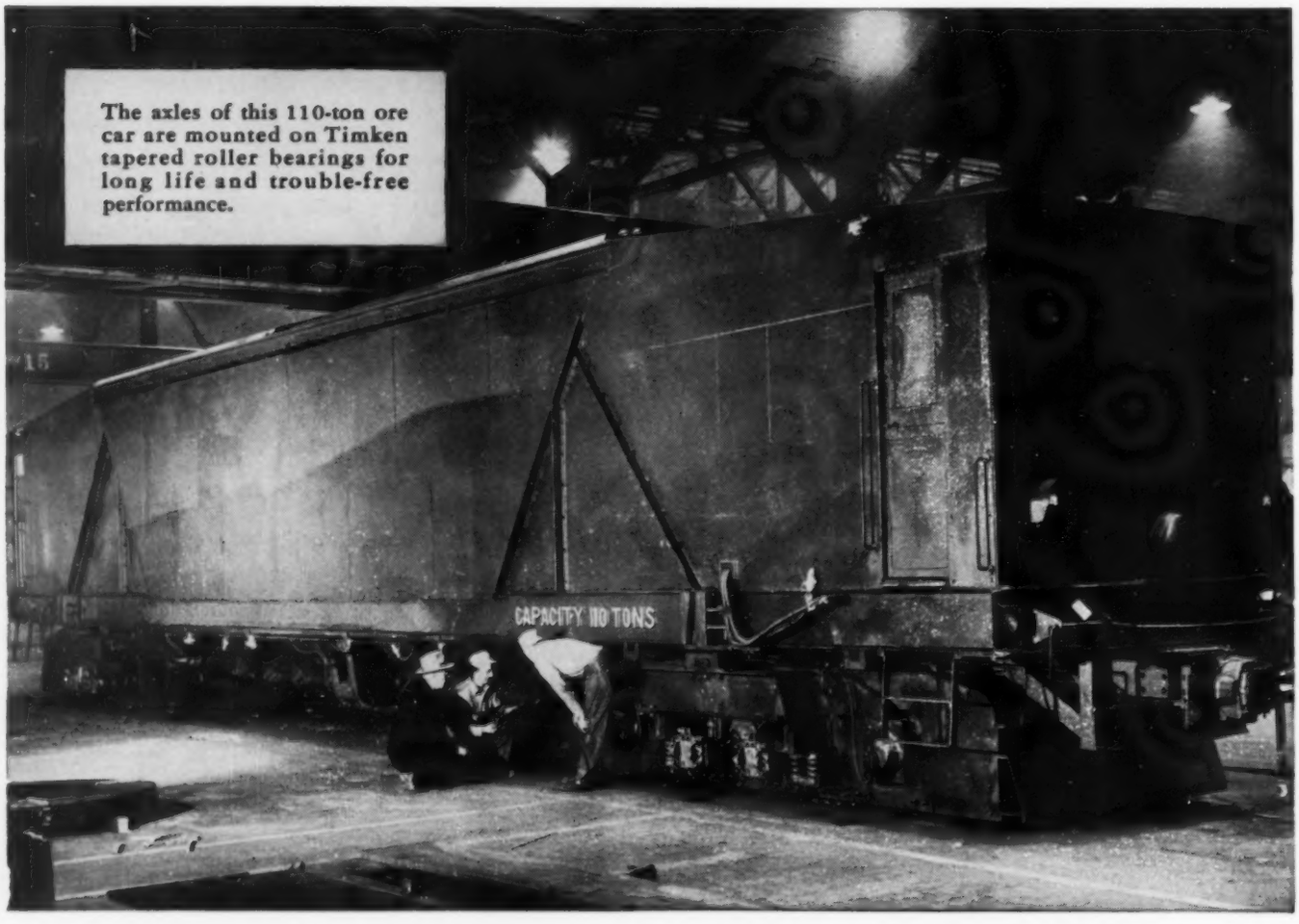
WHEN 110 tons of iron ore are dumped into the ore car pictured below, heavy shock loads hit the bearings on the axles. And when the car bounces over rough track, the bearings have to take repeated shock loads. That's one of the main reasons Timken® tapered roller bearings are used on the axles of this ore car and others like it in a large eastern steel mill.

Timken bearings easily take heavy shock loads because they are case-hardened so that they have tough, shock-resistant cores under hard, wear-resistant surfaces. They take the heavy pounding an ore car gets with minimum time-out for maintenance and repair. And because of full line contact between rollers and races, Timken bearings have extra load-carrying capacity.

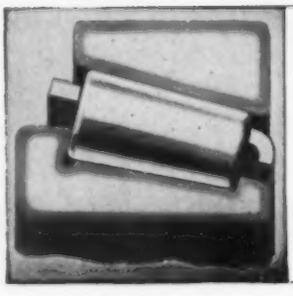
It's easy to start an ore car with Timken bearings on the axles. Timken bearings cut starting resistance 88%. That's because their true rolling motion and smooth surface finish practically eliminate friction.

And since Timken bearings are tapered, they take any combination of radial and thrust loads without the need for costly auxiliary thrust bearings. So whether you're building or buying mill equipment, make sure you get all the advantages only Timken bearings can give. For longer life, less friction, minimum maintenance, always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



The axles of this 110-ton ore car are mounted on Timken tapered roller bearings for long life and trouble-free performance.



HARD ON THE OUTSIDE, TOUGH ON THE INSIDE

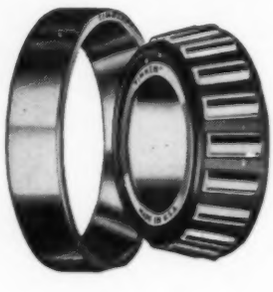
Rollers and races of Timken bearings are case-carburized to give a hard, wear-resisting surface and a tough, shock-resisting core. Result: longer bearing life.

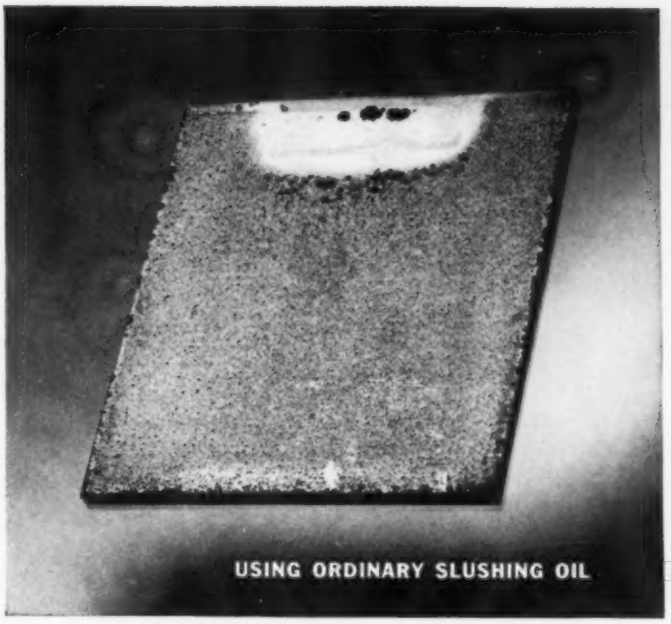
The Timken Company leads in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis Timken steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS





Humidity Cabinet Test proves superiority of new coating oil. Using ordinary slushing oil, steel test panel (on left) shows harmful rust after only 100 hours in humidity cabinet with relative humidity of 100% at 120 F. An identical steel test panel (above right), protected by new Sunkote A, shows no rust or stain whatsoever after 200 hours under same rust test conditions of high humidity and temperature.

ANNOUNCING SUNKOTE A

a new, low-cost rust preventive coating for hot and cold rolled strip and sheet steel

SUNKOTE A is easily applied by dip, roller, or spray. Special compounding provides extra protection against rust and stain at lowest cost.

Sunkote A is specifically compounded to protect hot and cold rolled strip and sheet steel against rust and stain for long periods in storage and in transit.

Economical to use, Sunkote A is moderately priced... gives maximum coverage and protection... can be applied by all usual methods... is easily removed by any of the normal cleaning processes.

For complete information about this new product, see your Sun representative...or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-12.

SUNOCO®

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY Philadelphia 3, Pa.

IN CANADA: SUN OIL COMPANY, LTD., TORONTO AND MONTREAL

It's Allis-Chalmers . . .

Motors, M-G Sets, Control, Switchgear... Dependable Allis-Chalmers Electrical Equipment Plays an Important Role in Steel Mill Expansion Programs

Demand for specialized steel remains at a record high. Steel producers are meeting the challenge with improvements on existing processing lines, or installation of new facilities for pickling and annealing operations.

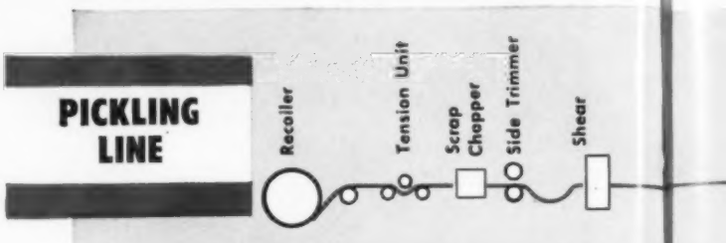
A recent installation of this type in an eastern steel mill featured Allis-Chalmers motors, m-g sets, control and operating stations, and switchgear throughout.

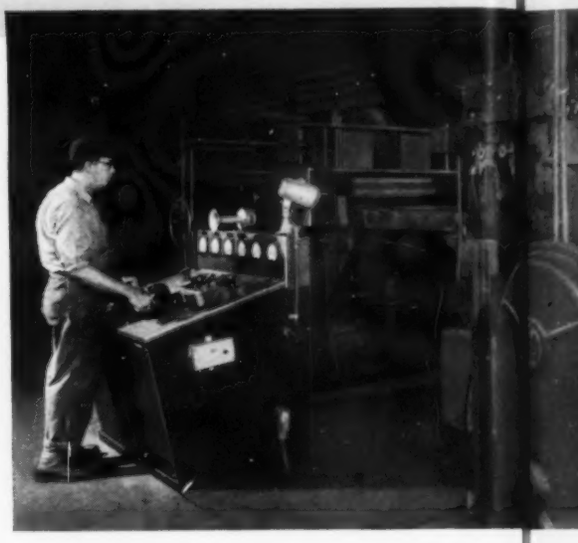
Allis-Chalmers equipment was chosen for this duty because of its record of quality, economy, durability . . . proven in years of heavy-duty steel mill operation.

Take advantage of Allis-Chalmers wide range of equipment and service. For help in planning new facilities or modernizing present plants, contact the A-C office in your district, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

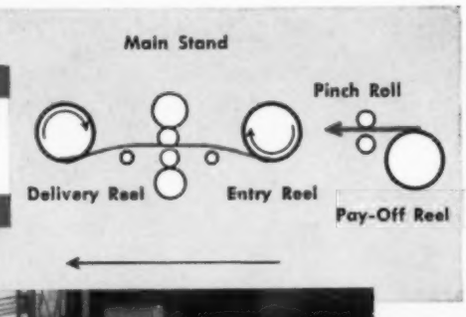
A-4872

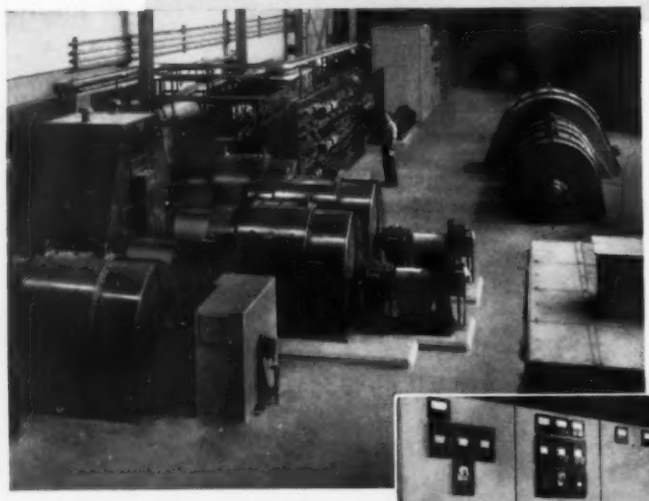
PICKLING LINE

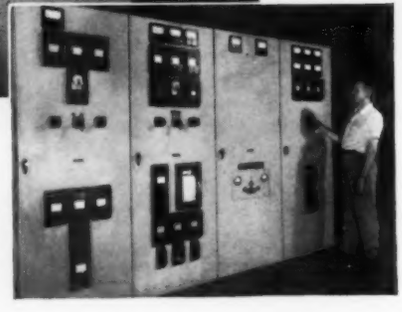




REVERSING MILL

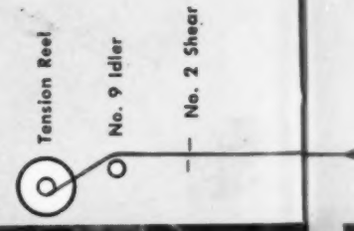






Overall view of new reversing mill motor room showing main motors, m-g sets, control, and 11,000/480-volt substation. Inset shows Allis-Chalmers 15-kv high voltage switching equipment for the motor-generator set and substation.

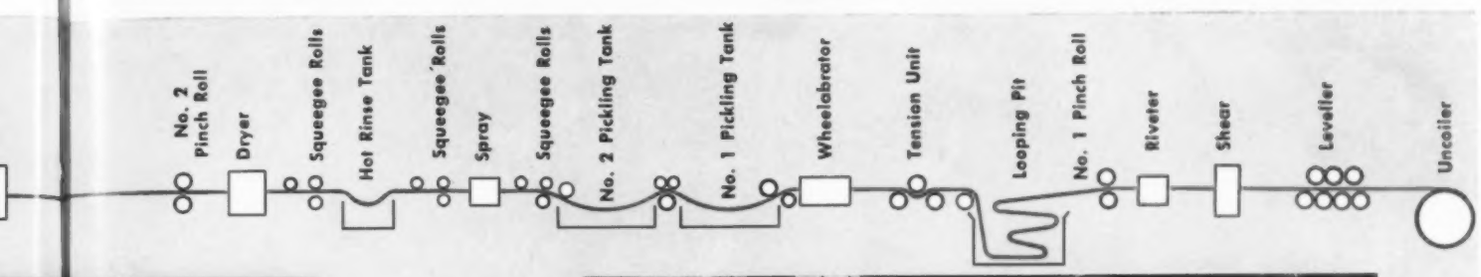
BRIGHT ANNEALING LINE

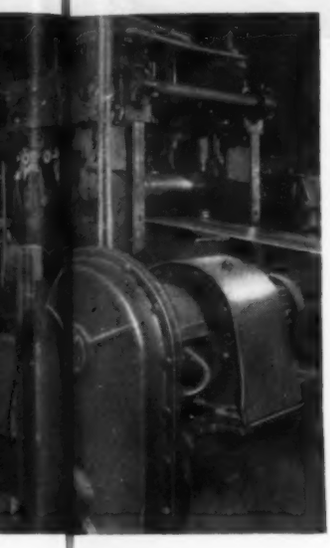


Delivery end of new annealing line. Allis-Chalmers desk-type operators' control stations, as shown here, are used throughout these modern new facilities.

ALLIS-

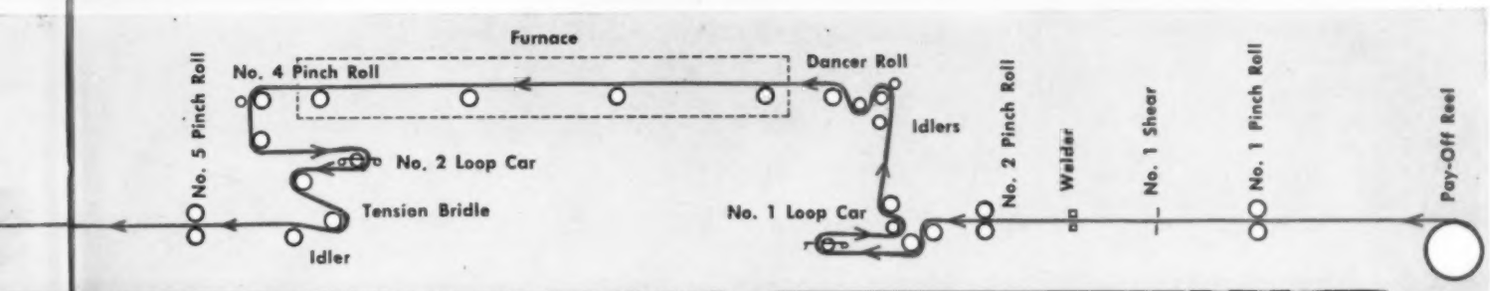
. . All Along the Line



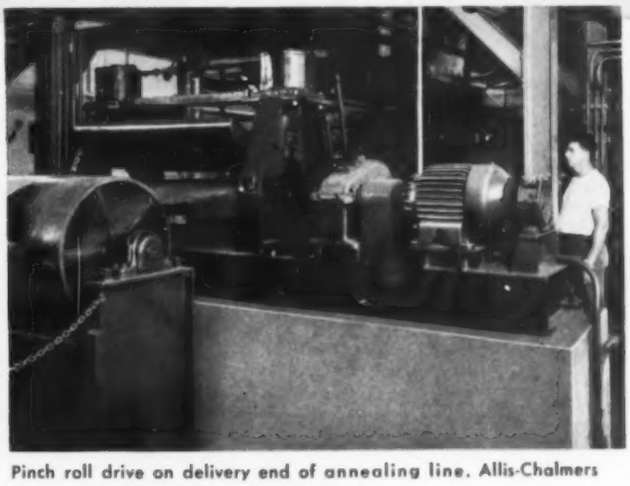


Operator's station, entry end, 36-inch hot-rolled pickling line. Allis-Chalmers control, initiated from desk, gives positive, precision control of material speed.

Allis-Chalmers dc control board and metering panels, m-g set, on delivery section of the pickling line.



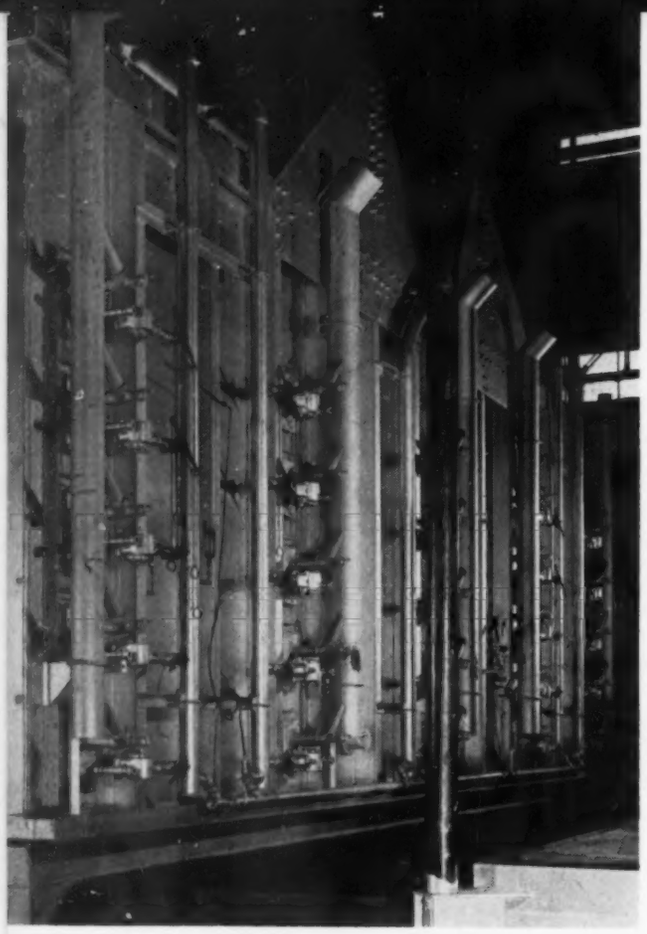
Allis-Chalmers m-g set and dc control board on the annealing line. Allis-Chalmers m-g sets and controls are recognized in the steel industry for dependable, economical service.



Pinch roll drive on delivery end of annealing line. Allis-Chalmers fan-cooled motors drive various parts of the processing line.

CHALMERS

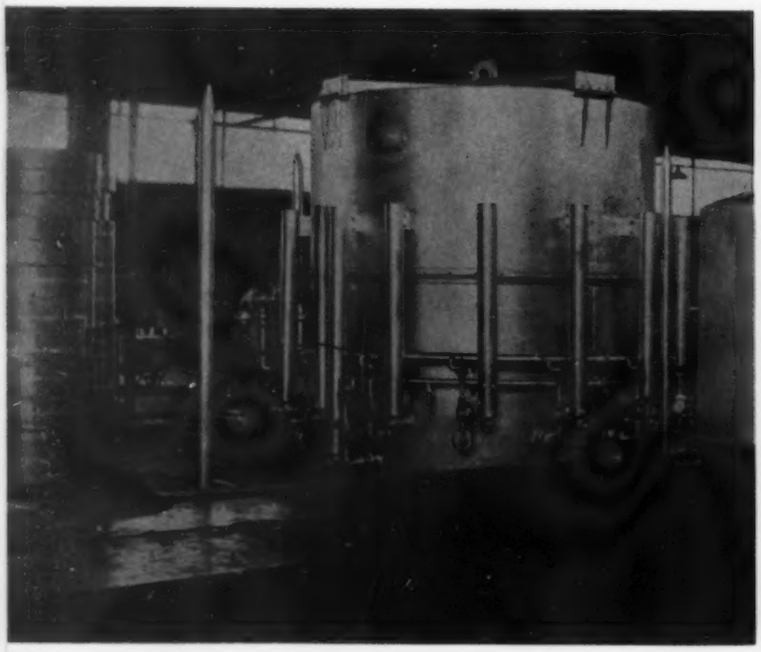
A-C ALLIS-CHALMERS



FOR
GENERATIONS
IN
STEEL

The top standard of excellence
in sheet and strip annealing

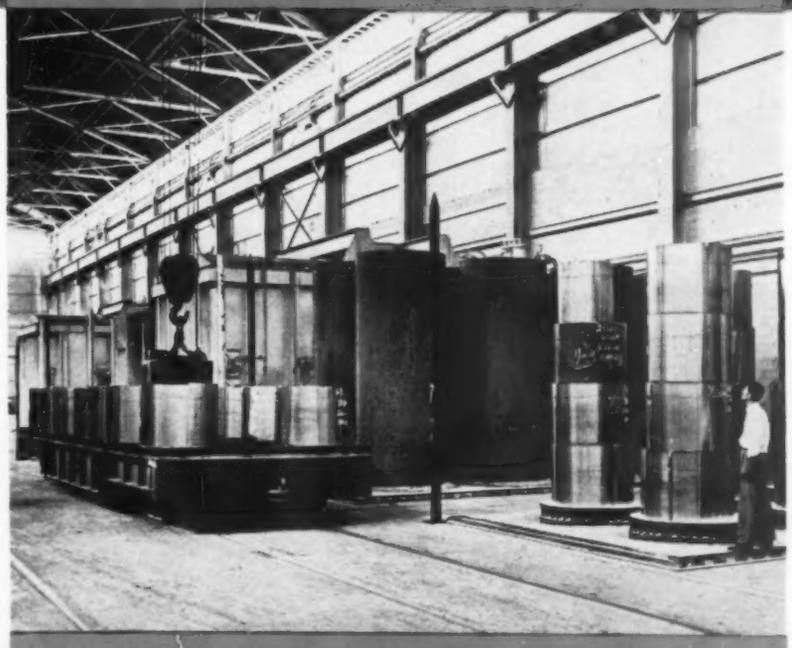
SWINDELL



INDUSTRIAL FURNACES

Since 1850

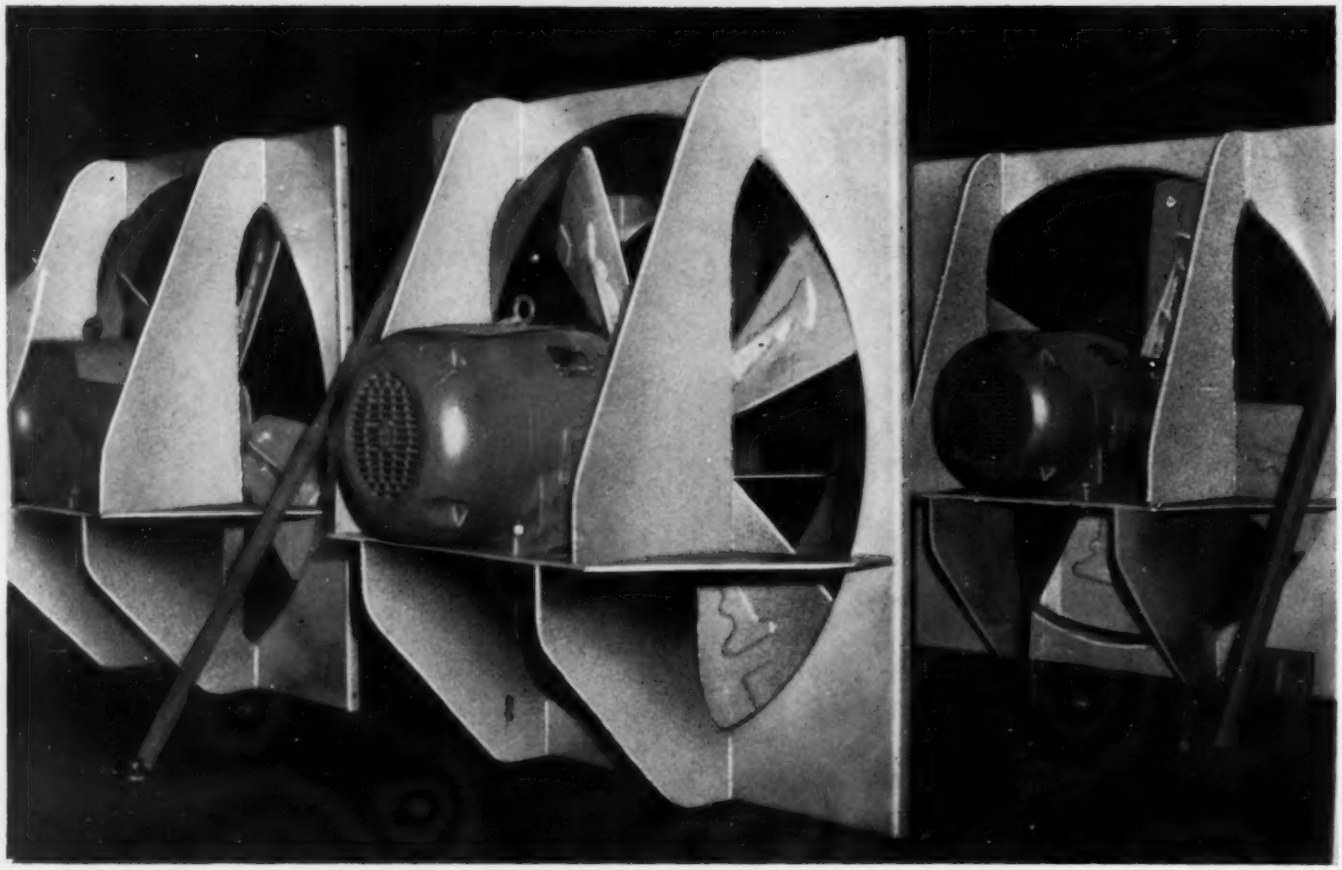
In design, construction and performance SWINDELL Annealing Furnaces set the pace in tonnage handling for America's largest sheet and strip producers. • Decade after decade, steady technological advances keep Swindell in the forefront of heating progress—and year after year, long-lived Swindell dependability returns dividends on every furnace investment. • For helpful consultation on your annealing requirements, write us.



SWINDELL-DRESSLER *Corporation*

DESIGNERS AND BUILDERS OF INDUSTRIAL FURNACES

PITTSBURGH 30, PENNSYLVANIA



Part of eleven "Buffalo" 54" Package Fans now ventilating the mill motor room of a large eastern strip mill.

Steel Plant SOLVES TOUGH MILL MOTOR ROOM VENTILATION PROBLEM

with "Buffalo" PACKAGE PROPELLER FANS

These heavy duty ruggedly constructed units are gaining wide acceptance in steel mill installations. Here, eleven of the above "Buffalo" units pull outside air in thru two banks of cleanable and electrostatic filters, discharging into the mill motor room. They're built to take this tough air moving job, too! Note the sturdy ¼" steel plate square flanged panels and the ⅜" steel plate support gussets welded to the panels. The heavy die-stamped blades are welded to rugged cast steel spiders. Motors are 15 h.p., 860 R.P.M.

What hot spots in your plant would you like to ventilate at propeller fan cost? "Buffalo" offers you the complete selection — sizes up to 144" wheels — power roof ventilators — all kinds of special models to suit your application. Write today for Bulletin FM-1234 and see the astonishing variety of jobs these "Q" Factor* fans are doing well and inexpensively.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY
173 MORTIMER ST. BUFFALO, NEW YORK
PUBLISHERS OF "FAN ENGINEERING" HANDBOOK
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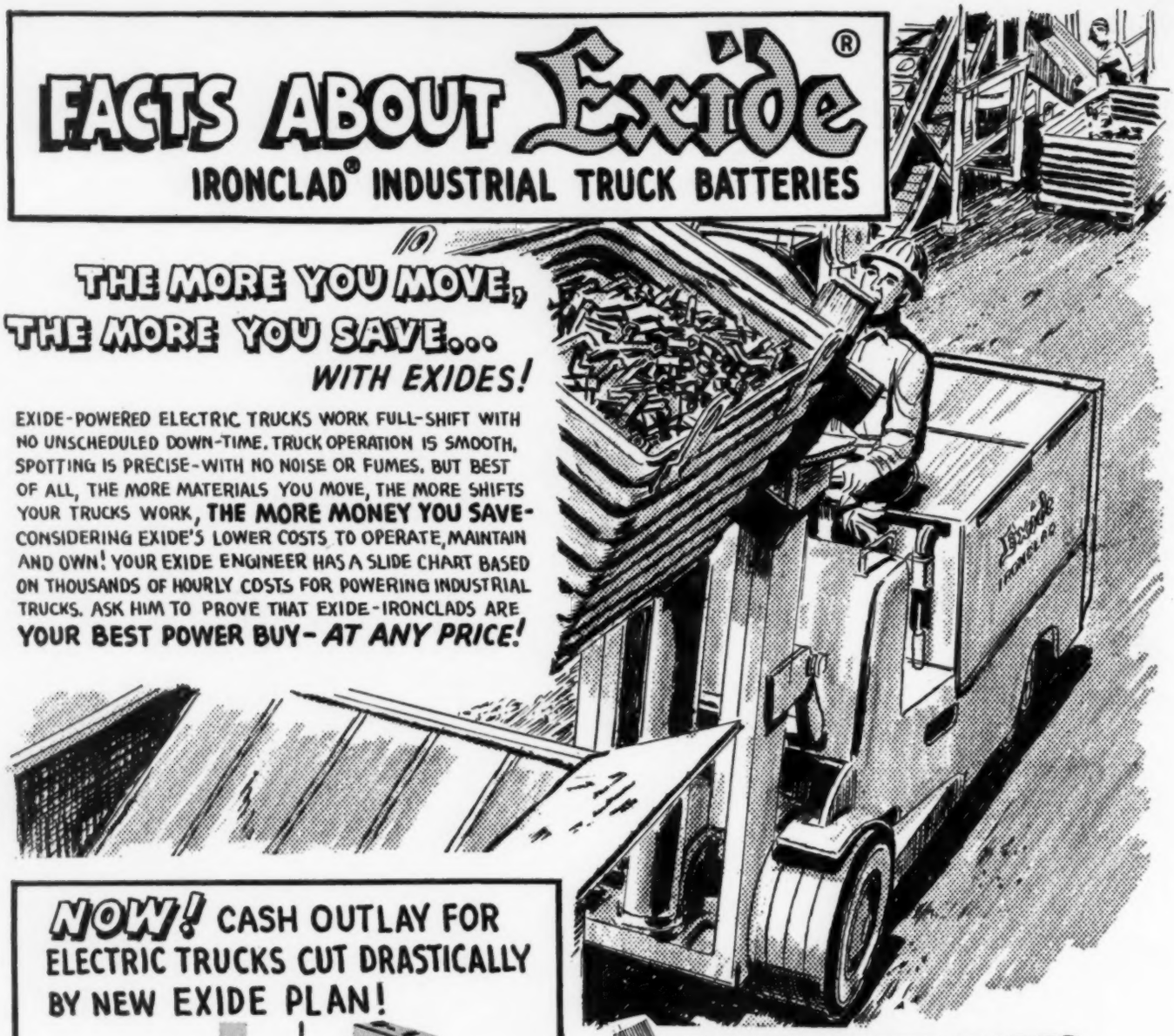
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

UNITED ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pa.

FACTS ABOUT Exide®

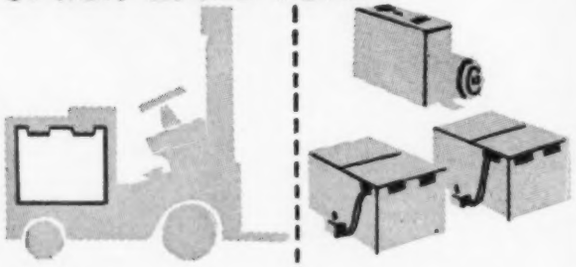
IRONCLAD® INDUSTRIAL TRUCK BATTERIES



THE MORE YOU MOVE, THE MORE YOU SAVE... WITH EXIDES!

EXIDE-POWERED ELECTRIC TRUCKS WORK FULL-SHIFT WITH NO UNSCHEDULED DOWN-TIME. TRUCK OPERATION IS SMOOTH, SPOTTING IS PRECISE—WITH NO NOISE OR FUMES. BUT BEST OF ALL, THE MORE MATERIALS YOU MOVE, THE MORE SHIFTS YOUR TRUCKS WORK, **THE MORE MONEY YOU SAVE**—CONSIDERING EXIDE'S LOWER COSTS TO OPERATE, MAINTAIN AND OWN! YOUR EXIDE ENGINEER HAS A SLIDE CHART BASED ON THOUSANDS OF HOURLY COSTS FOR POWERING INDUSTRIAL TRUCKS. ASK HIM TO PROVE THAT EXIDE-IRONCLADS ARE **YOUR BEST POWER BUY—*AT ANY PRICE!***

NOW! CASH OUTLAY FOR ELECTRIC TRUCKS CUT DRASTICALLY BY NEW EXIDE PLAN!



BUY ONLY THE TRUCK CHASSIS! CUT INITIAL CAPITAL OUTLAY AS MUCH AS 33⅓%!

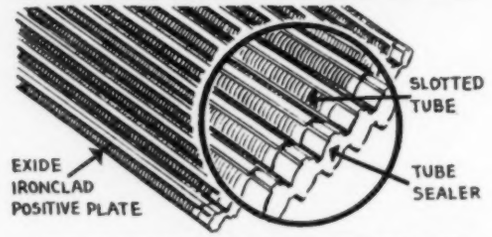
LEASE EXIDE-IRONCLAD BATTERIES AND CHARGER!

IN ADDITION TO THE SUPERIOR OPERATION OF ELECTRIC TRUCKS YOU GET BIG ANNUAL SAVINGS. A TYPICAL EXAMPLE OF HOW MUCH YOU SAVE EACH YEAR WITH ELECTRIC TRUCKS AND THE EXIDE PLAN:

1 TRUCK ON 3-SHIFT OPERATION SAVES $1425.76!

MAKE US PROVE THESE SAVINGS! CALL YOUR EXIDE SALES ENGINEER. ASK YOUR ELECTRIC TRUCK SALESMAN. WRITE FOR COMPLETE DETAILS ON THE EXIDE LEASING PLAN!

MAGIC POWER TUBES OF POLYETHYLENE!



NOW, ACID-PROOF, NON-CORRODING POLYETHYLENE PLASTIC TUBES AND SEALERS ARE INSIDE ALL EXIDE-IRONCLADS! DEVELOPED IN THE LABORATORY, TESTED IN THE FIELD, AND ALREADY PROVED IN CUSTOMER USE—THIS MIRACLE BATTERY MATERIAL IS THE LATEST IMPROVEMENT IN EXIDE-IRONCLADS. ITS USE GIVES YOU MORE POWER IN THE SAME SPACE! LONGER BATTERY LIFE! BETTER PERFORMANCE! LESS MAINTENANCE!

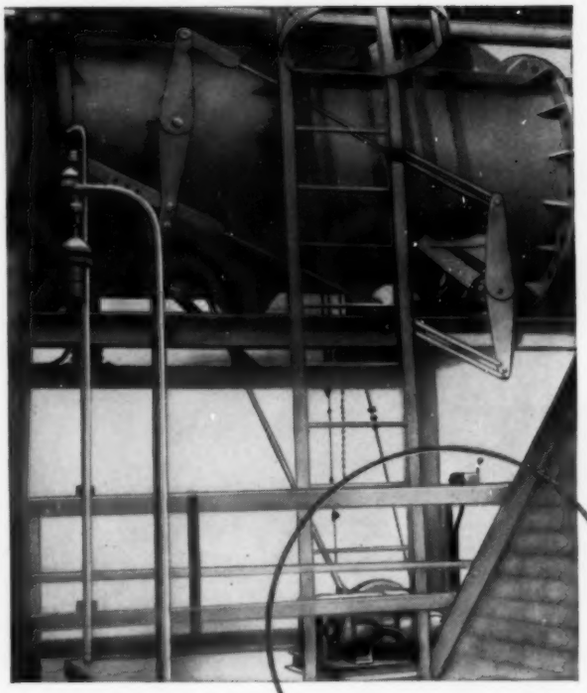
FOR THE AMAZING "INSIDE STORY" ON NEW EXIDE-IRONCLADS WITH POLYETHYLENE, CALL YOUR EXIDE SALES ENGINEER!

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

Freyn-Design MOTOR OPERATOR

For Any Blast Furnace Snort Valve

...Fast, Positive Power Operation!



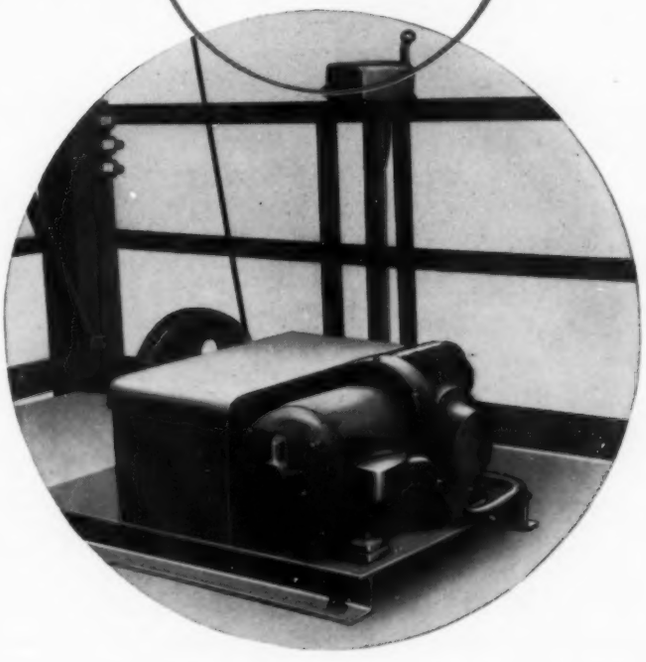
Located right at the snort valve, the Freyn-Design Motor Operator provides a direct mechanical drive between the snort valve operating shaft and the motor operator drive shaft. It is thereby not dependent on long cables extending from the cast floor handwheel.

A master switch for controlling the operator is located in the cast house. Additional switches can be easily installed, giving you the advantage of controlling the operator not only from the cast house, but also from *any* location desired.

In the event of electrical power failure, the motor drive automatically disconnects, permitting full use of the handwheel which is provided in the cast house for emergency manual operation.

There are seven installations of this type of Freyn equipment at three blast furnace plants—*and four of these installations were repeat orders!*

Write for booklet giving drawings and descriptive information, or consult with our engineers.



Top Photo: The snort valve at top responds quickly, is easier to control with the Freyn-Design Motor Operator shown at bottom.

Bottom Photo: Close-up of motor operator with one of several master switches (on top rail) in addition to the master switch in the cast house.

REPEAT ORDERS BASED ON PERFORMANCE

KOPPERS

KOPPERS COMPANY, INC.

Freyn Department

Engineering & Construction Division

KOPPERS BUILDING - PITTSBURGH 19 Associated with Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND; De Lattre & Freyard, Paris, FRANCE

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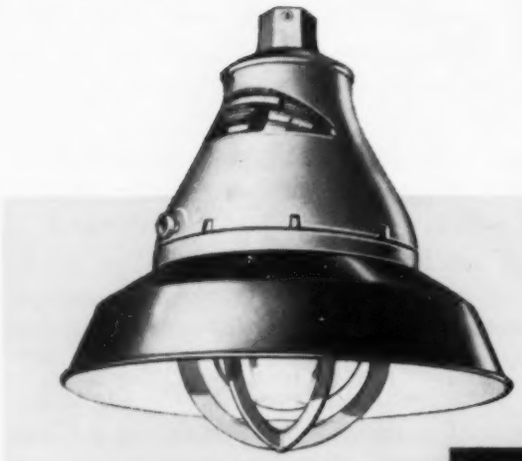

*Condulet**

EXPLOSION-PROOF FIXTURES

for N.E. Code Class I Locations

Operate at temperatures below ignition temperatures of surrounding explosive gas-air or vapor-air mixtures. Resist internal explosions without damage. Prevent escape of flames to surrounding atmospheres.

Condulet

DUST-TIGHT FIXTURES

for Class II Locations

Exclude combustible dusts from interior of fixture. Even when fixture is completely blanketed with dust, temperature of fixture will not cause ignition.

COME TO CROUSE-HINDS for Free-of-Charge Lighting Help . . .

CROUSE-HINDS Engineers will survey your layouts for lighting hazardous industrial locations . . . describe National Electrical Code safety regulations . . . suggest precautions to observe . . . recommend UL-approved fixtures for each danger-area, etc.

*Trade Name Registered

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FLUORESCENT FIXTURES

Fluorescent fixtures also available for Class I, Group C and D; Class II, Groups E, F and G; and Class III.

VAPORTIGHT FIXTURES

for Class III Locations

Protect bulb, receptacle and wiring from moisture and corrosive vapors in damp locations. Enclosures are designed to prevent entrance of fibers and flyings, escape of sparks, burning material or hot metal.

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Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period July 19, 1955 through August 23, 1955 . . . .

METHOD OF OPERATING A BLAST FURNACE

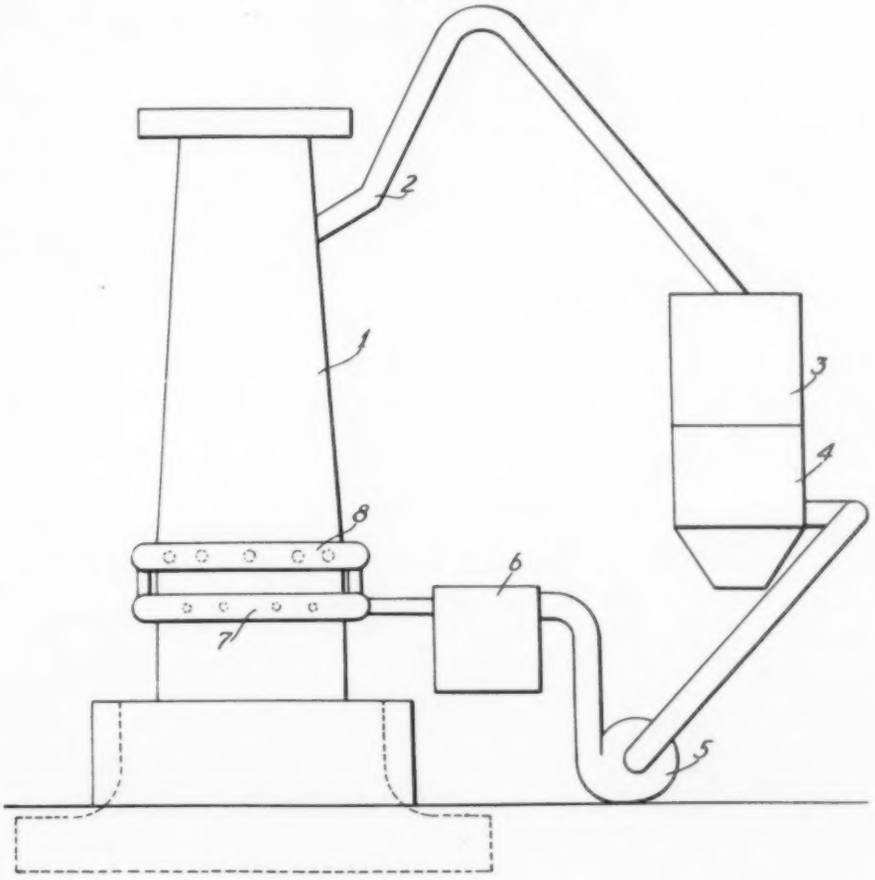
▲ U. S. 2,715,575, issued August 16, 1955 to Jay G. Coutant and assigned to Barium Steel Corp., describes a method of operating a blast furnace in which steam is injected into the high-temperature zone of the furnace.

The method of operation is described with relation to Figure 1. The numeral 1 represents a conventional blast furnace. Numeral 8 represents tuyeres through which an oxygen-containing gas is admitted in order to support combustion of the coke in the furnace charge. The numeral 7 represents tuyeres through which steam or hydrogen peroxide solution is admitted to the blast furnace for reaction with the coke to produce hydrogen and carbon monoxide. The numeral 2 represents a conduit through which the blast furnace gases are conducted to a dust separator, 3, and a humidifier 4. A fan 5, forces the humidified blast furnace gases through preheater 6, and tuyeres 7, back into the blast furnace. A portion of the gas is burned in the preheater, in order to heat the remainder of the gas up to the operating temperature.

The oxygen-containing blast gas preferably contains at least 40 per cent oxygen, and may be 100 per cent oxygen, thereby reducing the amount of nitrogen which must pass through the furnace carrying heat away and taking up half the volume of the apparatus.

Combustion of coke by an oxygen-enriched gas is highly exothermic, and it is this fact which would ordinarily lead to unduly high temperatures in the blast furnace, which has discouraged attempts to use a gas more concentrated in oxygen than air as the blast gas. However, the simultaneous injection of steam into the high-temperature zone has a marked controlling effect on the temperature produced. The reaction between steam and incandescent coke (carbon) to produce hydrogen and carbon monoxide is highly endothermic, (and incidentally is used the same way in the

Figure 1



production of water gas and producer gas). The injection of water vapor into the furnace is also beneficial in that the hydrogen produced is a very active reducing agent. Because of its small molecular size, its high molecular velocity, and its low viscosity as a gas, it has the ability to permeate solids such as iron ore to a much greater extent and more rapidly than other gases such as carbon monoxide.

In addition to the advantages cited above, it may be added further that blast furnace stoves of the usual type are unnecessary, since the gases charged to the furnace will be hot and contain water vapor which in conjunction with the oxygen admitted controls the temperature at the desired level.

Since the weight and volume of gas traveling up through the blast furnace are decreased by the reduction in the amount of nitrogen, it is possible to employ finer charges. By this arrangement, the ore may be pulverized to smaller particles, thus exposing greater surface area for the reactions. The decrease in nitrogen also increases the reaction rates, because nitrogen acts as a diluent, decreasing the concentration of the reducing gases.

PRODUCTION OF SILICON STEEL

U. S. 2,715,064, issued August 9, 1955 to Lawrence M. Burns, describes a method of producing the higher grades of electrical steels, such as transformer grades containing 3 to 4.5 per cent silicon.

In making such grades of steel, low-carbon steel is prepared in an open hearth furnace and is then tapped into a holding ladle containing ferrosilicon. A considerable amount of heat is evolved, due to the formation of SiO_2 and to the solution of silicon in iron. As a result, the temperature reached is too high for teeming, and it is therefore necessary to hold the steel in the ladle for 10 to 90 minutes. Furthermore, the temperature reached is too high for ladle refractories of the type used for stopper rods and teeming nozzles, and therefore the first ladle is generally of the lip-pouring type. This results in a pronounced lowering of the life of the refractory linings of the ladles and an increase of nonmetallic inclusions in the steel.

The solution presented to this problem is extremely simple. The temperature is lowered sufficiently by adding cold silicon steel scrap to the molten steel while in the first ladle.

FEEDING OF METALLIC MATERIALS TO CUPOLAS

U. S. 2,714,458, issued August 2, 1955 to Arthur Croft, William Hammond, and Maurice T. J. Goff, and assigned to Crofts (Engineers) Ltd., describes a device for feeding metal borings, turnings or grindings to a cupola furnace in controlled amounts.

ROTATING GRATE MECHANISM FOR SHAFT FURNACES

U. S. 2,714,457, issued August 2, 1955 to Carl Djuvik and assigned to Jones & Laughlin Steel Corp., relates to shaft furnaces used for heat-treating pellets of finely divided ore concentrates. The charge of pellets at the bottom of the furnace, supported by the furnace grates, is partially fused, so that it must be broken up to some extent as it is discharged. The layer of charge resting on the furnace grates is broken by rotating these grates, as described in the patent.

TRIMMING WELDED JOINTS IN STRIP METAL

U. S. 2,714,339, issued August 2, 1955 to Franz J. Waldschutz and assigned to Mesta Machine Co., describes apparatus for completely removing the flash from welded joints in continuous strips of metal.

A system is provided for holding the welded joint between cutting blades and swinging the cutting blades in successive arcs having their nearest approach at the weld line until the projecting flash is entirely removed, and in addition the thicker of the two welded coils is tapered to the thickness of the abutting thinner end. The resulting joint is smooth and ridgeless, and reduces wear on the processing equipment through which the joint subsequently passes.

AGGREGATE COMPOSITION OF GRANULATED SLAG AND EXPANDED VERMICULITE

U. S. 2,715,583, issued August 16, 1955 to George E. Ziegler and assigned to Zonolite Co., describes an aggregate composition consisting of granulated or expanded blast furnace slag and vermiculite as a plaster aggregate by itself or in combination with gypsum, lime, Portland cement, bentonite, or other binders. It is used as an applied plaster or stucco, and for use in forming slabs or sheets.

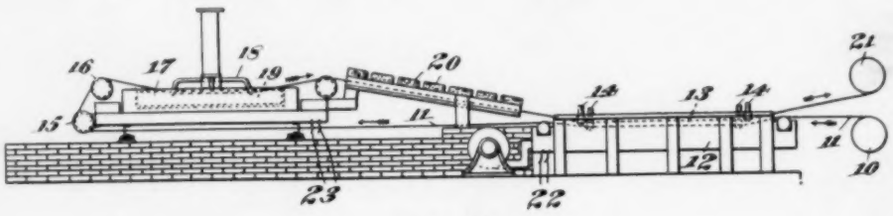


Figure 2

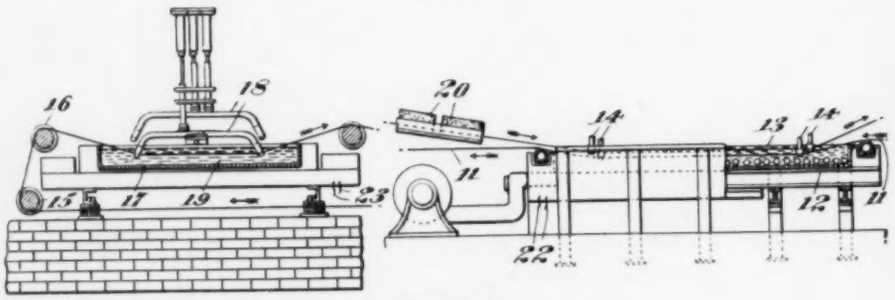


Figure 3

ELECTRICAL HEAT TREATING OF WIRE

U. S. 2,716,079, issued August 23, 1955 to Richard M. Wick, Stewart H. Jones and Samuel W. McClemens, and assigned to Bethlehem Steel Co., relates to the continuous annealing or patenting of wire. Heating is accomplished by passing an electrical current through the wire as it passes continuously through the apparatus.

The apparatus is shown in Figures

Shearing* LINES

Designed and Built by MESTA

MESTA 60" SHEET SHEARING LINES
WITH TRIMMERS AND COMBINATION
FLYING SHEARS AND LEVELLERS

* *HIGH-SPEED SHEARING, SIDE TRIMMING AND SLITTING EQUIPMENT FOR SHEET AND TIN GAUGE STRIP STEEL*

Designers and Builders of Complete Steel Plants

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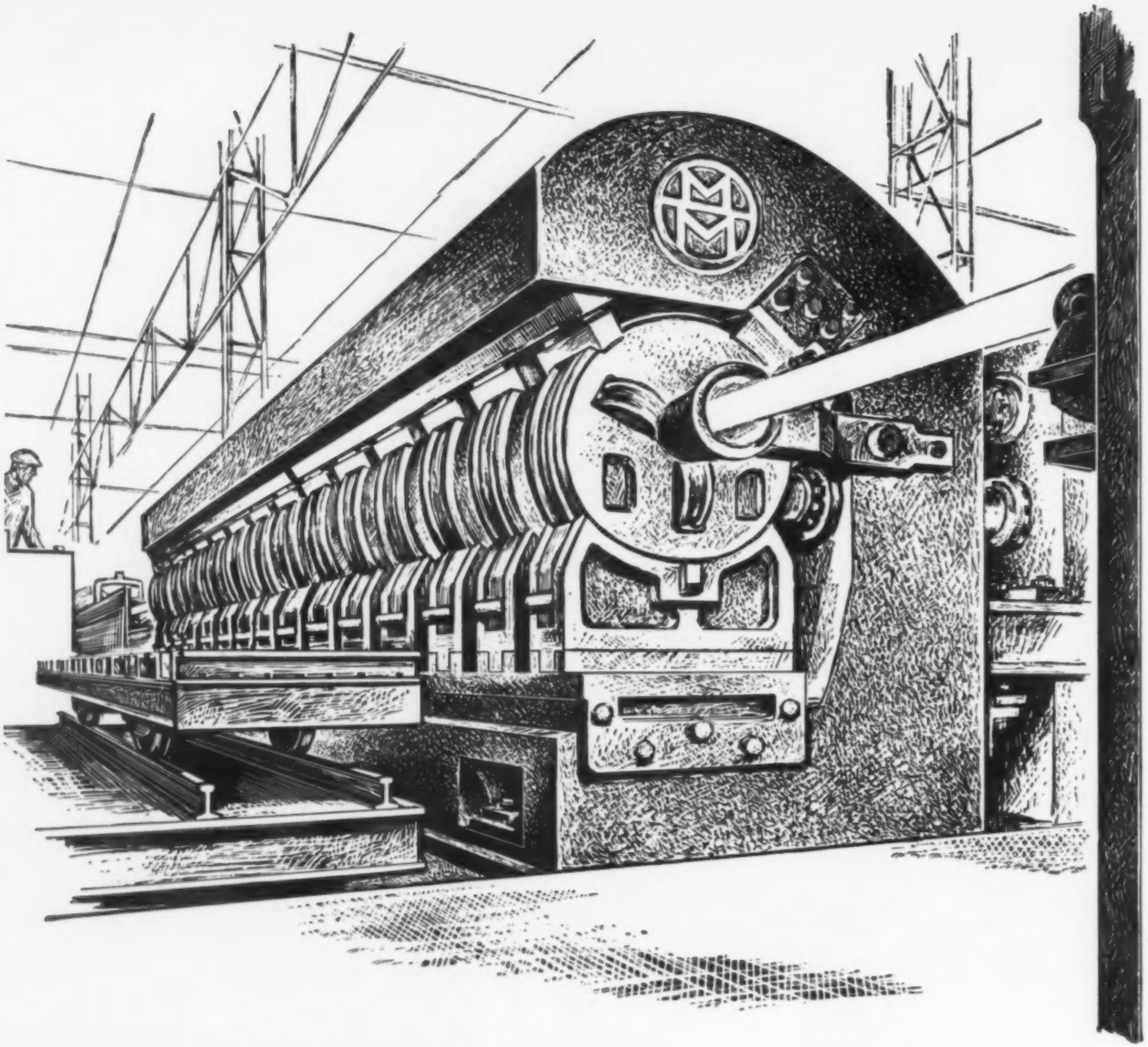

Want Higher Pipe Production?

Stretch reducing to increase tonnage rating of existing pipe welding mills or to increase the potential output of new mills is one of the recent production improvements at Mannesmann-Meer. Welding or rolling large diameter standard sizes boosts tonnage of the original mill and puts the stretch mill to work to produce the smaller sizes.

But that's only half of the story. By applying the 3-roll arrangement to the stretch reducing mill, greater diameter and outstandingly high wall reductions together with an improved mill finished product have been made possible. Moreover, basic changes in overall mill design include a revolutionary new mill drive and an ingenious roll stand arrangement to suit today's need for extremely fast schedule changeover.

Plan ahead and develop today what you will ask for tomorrow is Mannesmann-Meer's approach to the problems of the pipe and tube industry. This leads to the design of equipment incorporating a combination of

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WORLD SPECIALISTS IN HIGH-SPEED TUBE MILL MACHINERY

2 and 3 in which there is shown feed-in reel, 10, from which a number of wires, 11, to be treated are led into the first contact pot, 12, in which there is maintained a bath of molten lead, 13. Contact pot, 12, which is also the quench pot, is at ground potential. Sinkers, 14, serve to keep incoming wires, 11, well beneath the surface of the molten metal and below the level of the outgoing wires. From contact pot, 12, wires, 11, travel horizontally as far as driven capstan, 15, at which point the direction of travel of wires, 11, is reversed. This driven capstan is of benefit to the operation through its action of tension relief, without which inferior metallurgical properties are obtained in the wire being heat treated. The capstan is made of a heat resistant, dielectric material and is insulated from the ground. The capstan is made effective by either synchronous speed or over-drive involving a small amount of slippage, usually between 5 and 10 per cent. From capstan, 15, wires, 11, travel over sheave, 16, and down into second contact pot, 17, which is at operating potential. Sinkers, 18, hold the wires beneath the surface of molten metal, 19, in contact pot, 17. The sinkers, 18, are controllable, being pneumatically actuated by remote control, and serve to raise the wire out of the lead to disconnect the wire from the electrical circuit. This is useful in operation where changes are being made in remote parts of subsequent processing steps. From contact pot, 17, the wires travel back to pot, 12, traveling through guide structure, 20. Guide structure, 20, which is made of dielectric material contains a number of paths to accommodate the number of wires being heated and to keep them out of contact with each other during this stage of treatment. During this stage of their travel the wires are heated up by the current to the desired temperature of treament. Upon entering contact pot, 12, wires, 11, are quenched in the molten metal, 13, leave pot, 12, and are wound on take-up reel, 21. Wires, 11, upon entering pot, 12, from the feed-in reel and upon leaving pot, 12, after being quenched, are at ground potential.

The molten metal in contact pots, 12 and 17, is connected by electric cables, 22 and 23, to a source of supply of a current of electricity which is subject to automatic voltage control.

It will be noted that the heat given up by the wire in quenching is used to preheat the incoming wire, thereby providing good thermal efficiency.

The wire being treated is at ground potential when it enters and when it leaves the apparatus, thereby eliminating hazards to the operators.

Because of the tension control afforded by the intermediate driven capstan a wider range of wire sizes can be heat treated by this method than heretofore, without changing the physical arrangement, e.g., the distance through which the wire is electrically heated. This improvement is important in operations. For example, it was found possible without changing any distances involved to electrically patent wire of 0.30 in. diameter at one extreme and 0.028 in. diameter at the other.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,713,418	7/19/55	Press for extruding billets	Hydropress, Inc.
2,713,480	7/19/55	Heat treating apparatus	Alfred Ruckstahl
2,713,481	7/19/55	Cupola lining including railroad rails	Modern Equipment Co.
2,714,065	7/26/55	Method of producing machining steel	Bethlehem Steel Co.
2,714,552	8/ 2/55	Direct condensate cooler in flue gas generator	Surface Combustion Corp.
2,714,787	8/ 9/55	Abrading machine	United States Steel Corp.
2,714,959	8/ 9/55	Wet electromagnetic separator and method	United States Steel Corp.
2,714,966	8/ 9/55	Furnace charging machines	The Wellman Smith Owen Engineering Corp.
2,715,083	8/ 9/55	Method of applying sulphide coating on stainless steel	Parker Rust Proof Co.
2,715,701-2	8/16/55	Motor regulation for strip tension control	Westinghouse Electric Corp.
2,715,958	8/23/55	Chain conveyor for handling pierced billets and mandrel bars	United States Steel Corp.
2,715,959	8/23/55	Multiblock wire-drawing apparatus	John A. Roebling's Sons Corp.

1956 AISE SPRING CONFERENCE

April 30, May 1, 2

Lord Baltimore Hotel Baltimore, Md.

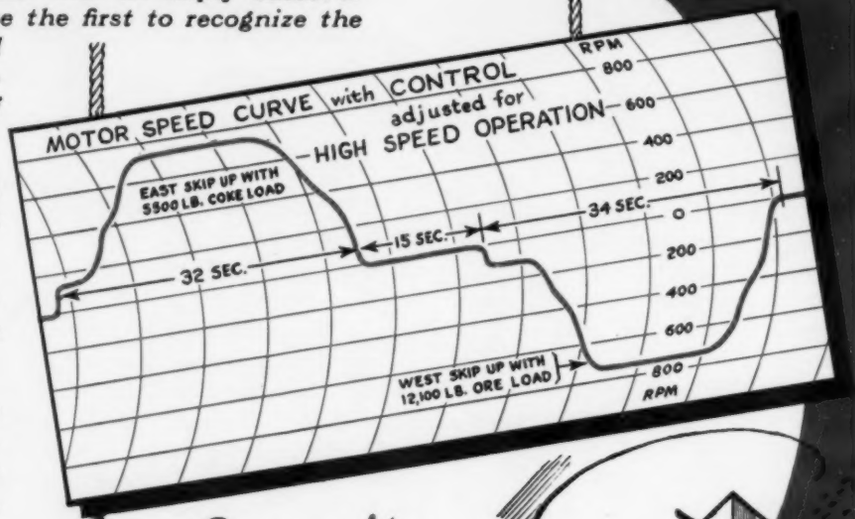
4 BIG ADVANTAGES IN SKIP HOIST OPERATION WITH EC&M LINE-ARC CONTACTOR CONTROL

1 *Adjustable Control* allowing up to double the running speed on the straight part of the track for reduced charging-time. Full field strength and maximum torque for acceleration, and at slow-down for accurate stopping—either with an empty bucket or capacity ore load. (*EC&M were the first to recognize the advantages of adjustable field control to speed up the skip-hoist on the straight part of the track.*)

2 *Low Initial Investment*—and low stand-by renewal part inventory.

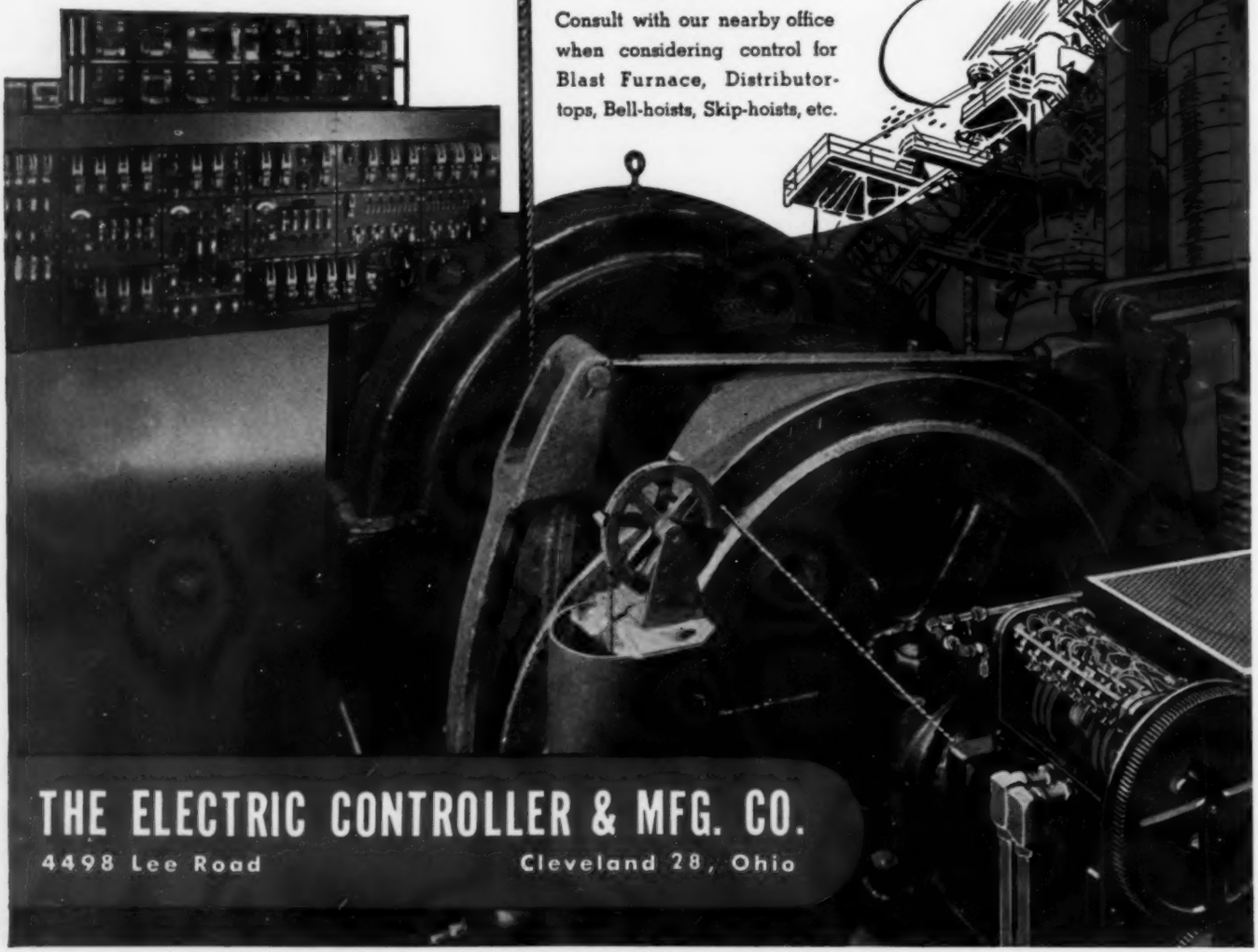
3 *Simple Construction Easily Inspected*—with minimum labor and up-keep expense.

4 *Safe, Smooth Operation* under all conditions of load. The accompanying curve shows this clearly and is typical of the economical, smooth and efficient operation obtained with this control.



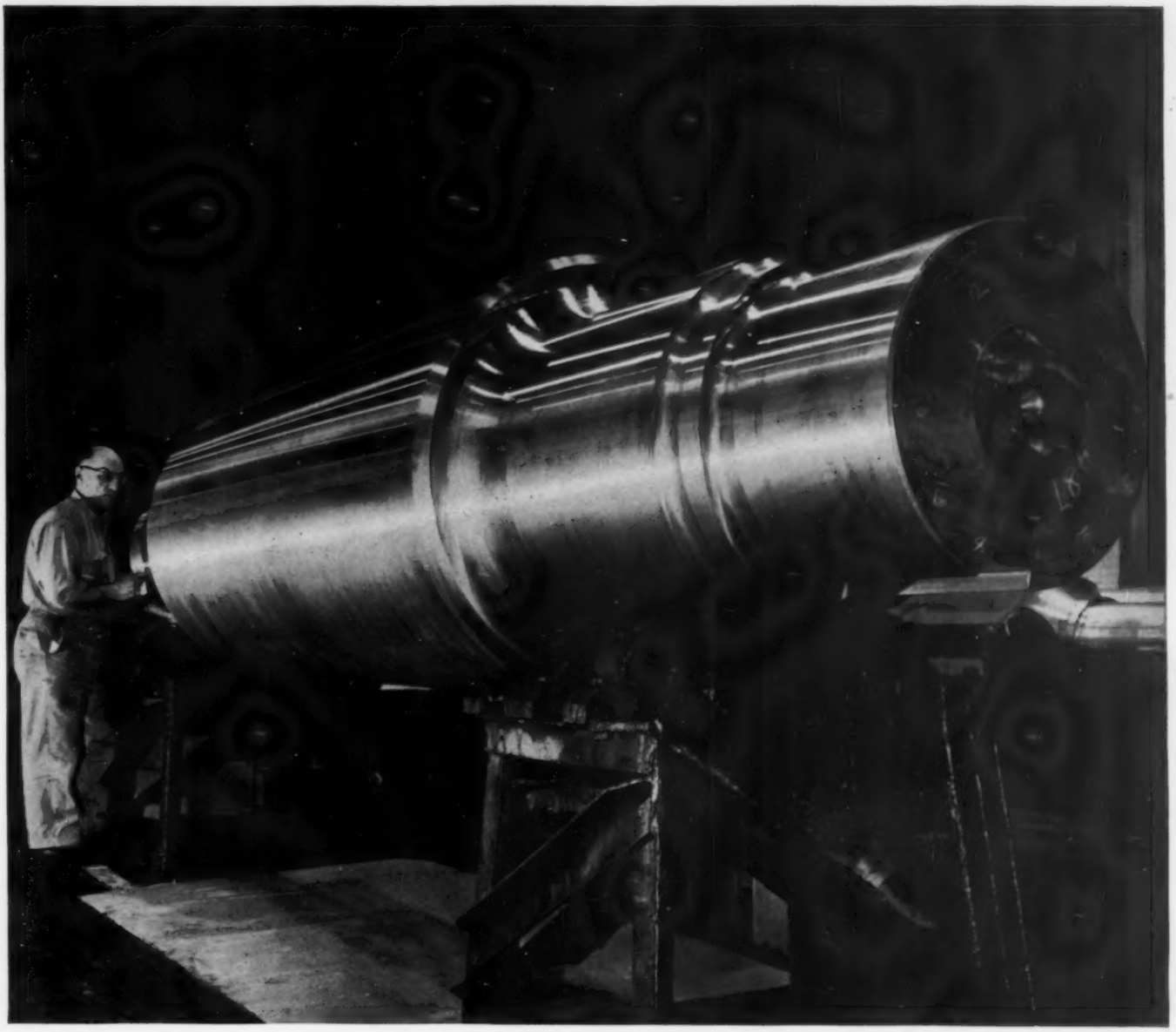
Consult

Consult with our nearby office when considering control for Blast Furnace, Distributor-tops, Bell-hoists, Skip-hoists, etc.



THE ELECTRIC CONTROLLER & MFG. CO.

4498 Lee Road Cleveland 28, Ohio



They Don't Come Much Bigger

Here's a forged-steel roll that's just about ready for shipment from the Bethlehem shops. It's a beautiful job, and a real whopper —weighs upwards of 22 tons. Sixteen feet long, the roll has a body diameter of approximately 38 in. You won't find them much bigger than this in the metal-rolling industry.

There's something downright impressive about such giants. It isn't only their tonnage; it's a combination of size, graceful contours, and smooth, glistening finish. Bethlehem makes quite a few of them, and in every case our shop craftsmen are shooting for perfection.

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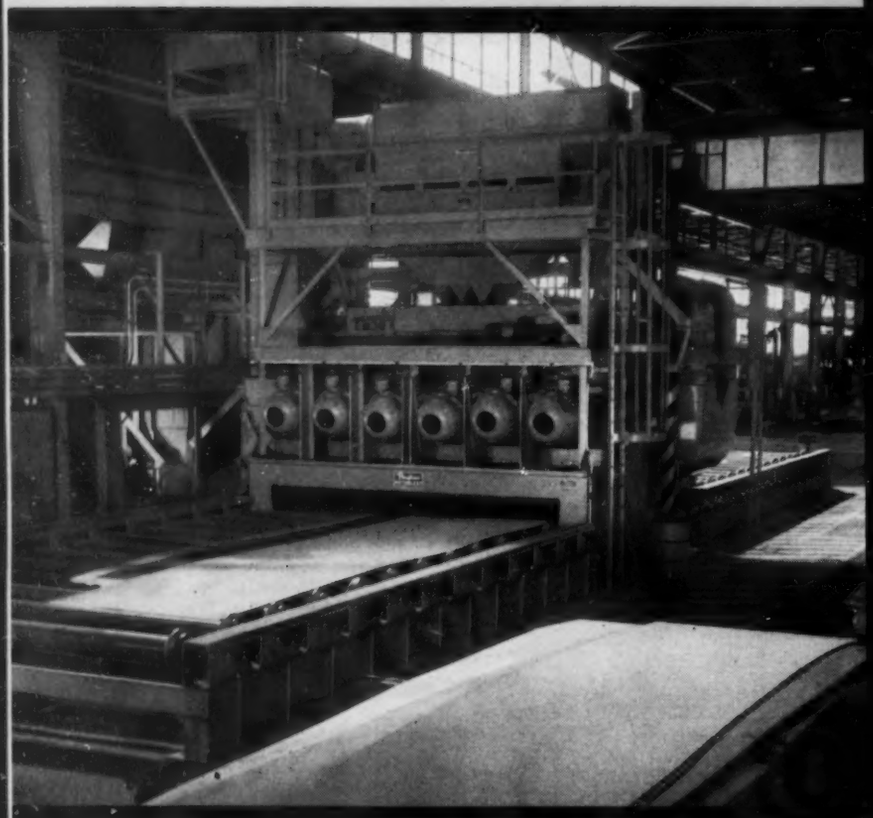
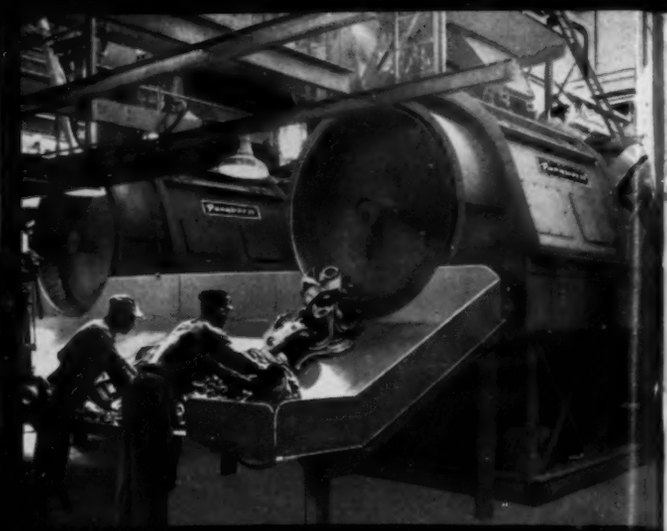
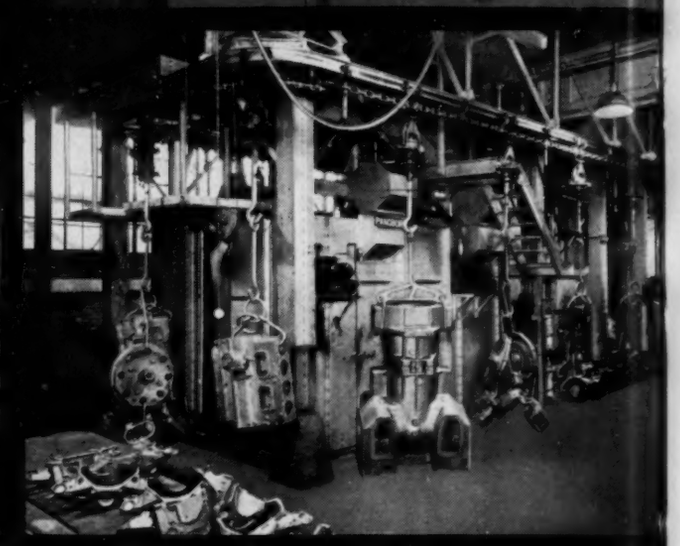
BETHLEHEM STEEL

BETHLEHEM STEEL

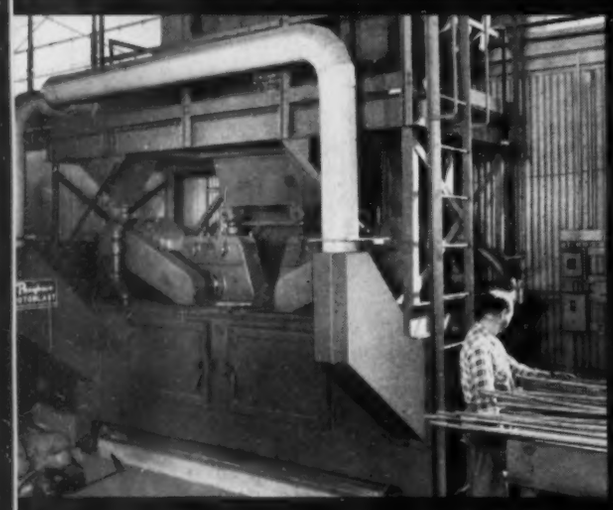
If you have







an unusual blast cleaning problem,



If you are a company with a special cleaning problem, Pangborn offers you a special service—a machine designed for your individual needs. It might be a descaling machine for bars, sheets and coils, a continuous-flow barrel or a monorail cabinet like the machines shown here . . . or it might be completely different. You may need to clean cylinder blocks, bathtubs or any unusual ferrous or nonferrous castings, forgings, stampings. If so, Pangborn engineers will study your problem and its relation to your production line. Then they'll design a Pangborn machine that gives you better cleaning and faster production at lower cost. Pangborn has proved it in hundreds of cases. Pangborn can prove it to you! Write today for Bulletin 1210 to: PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

*U. S. Pat. #2184926 (other patents pending)

Pangborn Rotoblast® can solve it!

Pangborn

BLAST CLEANS CHEAPER

Rotoblast Blastmaster® & Continuous-Flo Barrel

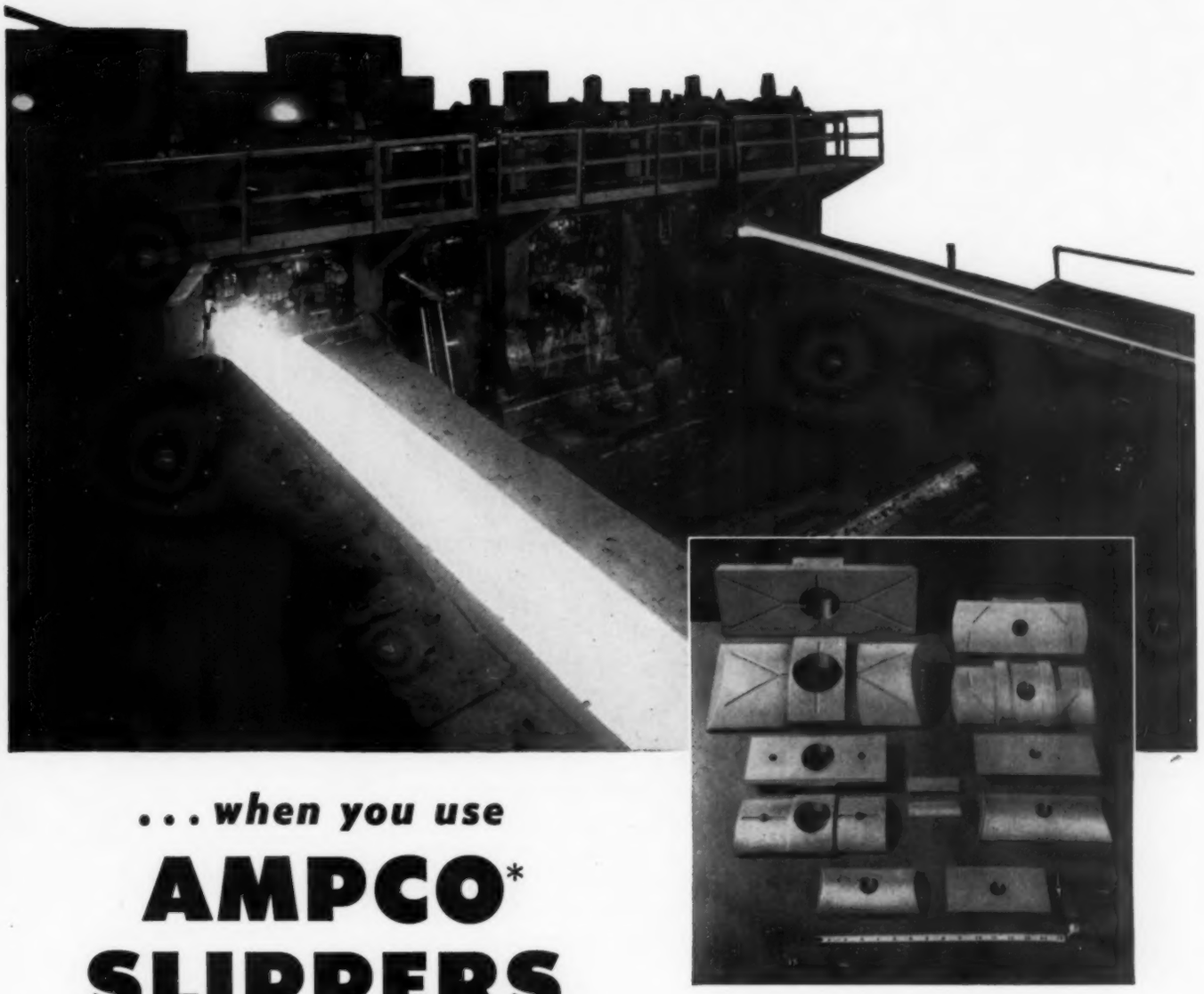
Rotoblast Tables & Table-Rooms

Special Blast Rooms & Cabinets

Pangborn Dust Control Equipment

Malleabrasive* Shot & Grit

Production Steps Up Costs Step Down



. . . when you use AMPCO* SLIPPERS

THERE'S plenty of "plus value" in slippers cast of Ampco Metal. They're tough — have unusual resistance to wear. They withstand the tremendous impacts and shock loads of steel-mill operation without squashing out. They have high fatigue strength.

These properties mean lower costs for you — less downtime — longer runs without replacement.

You get these slippers in the form you need to meet your specific operation. They're available "cast-to-size" or as rough castings. "Cast-to-size Slippers" come either with tolerances of minus 0, plus 1/32; or plus 0, minus 1/32. Oil grooves are cast in, if you want them.

And that's not all. Ampco Metal's stamina, toughness, and corrosion resistance mean that it's ideally suited for cutting costs in other steel-mill applications, too — screw-down nuts, wear plates, flash-welder dies, pickling equipment. Get the whole money-saving story from your nearby Ampco field engineer or write us direct

G-20

*Reg. U. S. Pat. Off.

AMPCO METAL, INC.

DEPT. 15-12, 740 S. 38TH STREET
MILWAUKEE 46, WISCONSIN

West of the Rockies it's Ampco's Burbank Plant, Burbank, California

Pumping Progress Report

FOR HYDRAULIC ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

SPACE, in many pump installations, is a major problem. Another is the necessity for special foundations. When new installations are considered, these factors may dictate more elaborate construction than should be necessary. And for replacement or modifications of existing systems, they may require expensive piping and equipment changes.

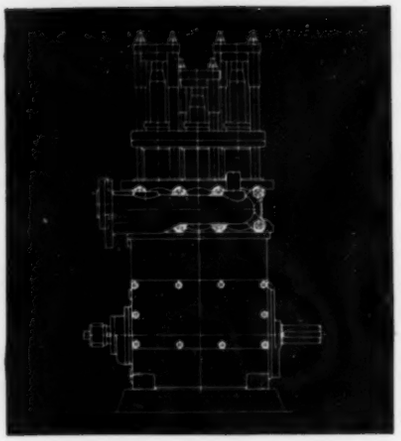
COMPACTNESS OF DESIGN, while often desirable, is not necessarily the answer. Simplicity of design — as in the case of ALDRICH Direct Flow Pumps — may be a better solution.

SIMPLICITY OF DESIGN brought about the first inverted Triplex and Quintuplex Pumps and ultimately Septuplex and Nonuplex Pumps. This Aldrich design innovation brought to pump users many economies of space, maintenance and operation they had never known.

INVERTED PUMP DESIGN permits the use of less expensive foundations. With the crankshaft located near the floor there is no need for expensive foundation work to raise the driver or lower the pump. Then, too, inverted pumps require fewer square feet of floor space than conventional pumps.

MAINTENANCE COSTS ARE REDUCED. Fluid-end, where most work is done, is at chest level. Bearing replacements are made without removing heavy crankshafts or connecting rods. Crossheads on all Direct Flow Pumps can be worked on or removed from pump without disturbing fluid-end.

TELL US ABOUT YOUR PUMPING PROBLEM. The chances are that one of our standard pumps — or a modification of one — will do your job. Detail your problem and we'll send you a copy of the Data Sheet that describes the Direct Flow Pump we recommend. Write to: The Aldrich Pump Company, 21 Pine Street, Allentown, Pa.



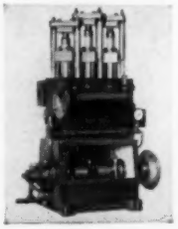
Aldrich inverted vertical pump design

...for your tough pumping problems specify ALDRICH

The entire line of Aldrich Direct Flow Pumps feature two outstanding design innovations—inverted vertical design and sectionalized fluid-ends. These two features have helped make Aldrich the organization hydraulic engineers turn to when they face tough pumping problems. If you have a pumping problem, turn it over to the men who have never turned down a challenge.

CHECK THESE ADVANTAGES OF INVERTED PUMP DESIGN:

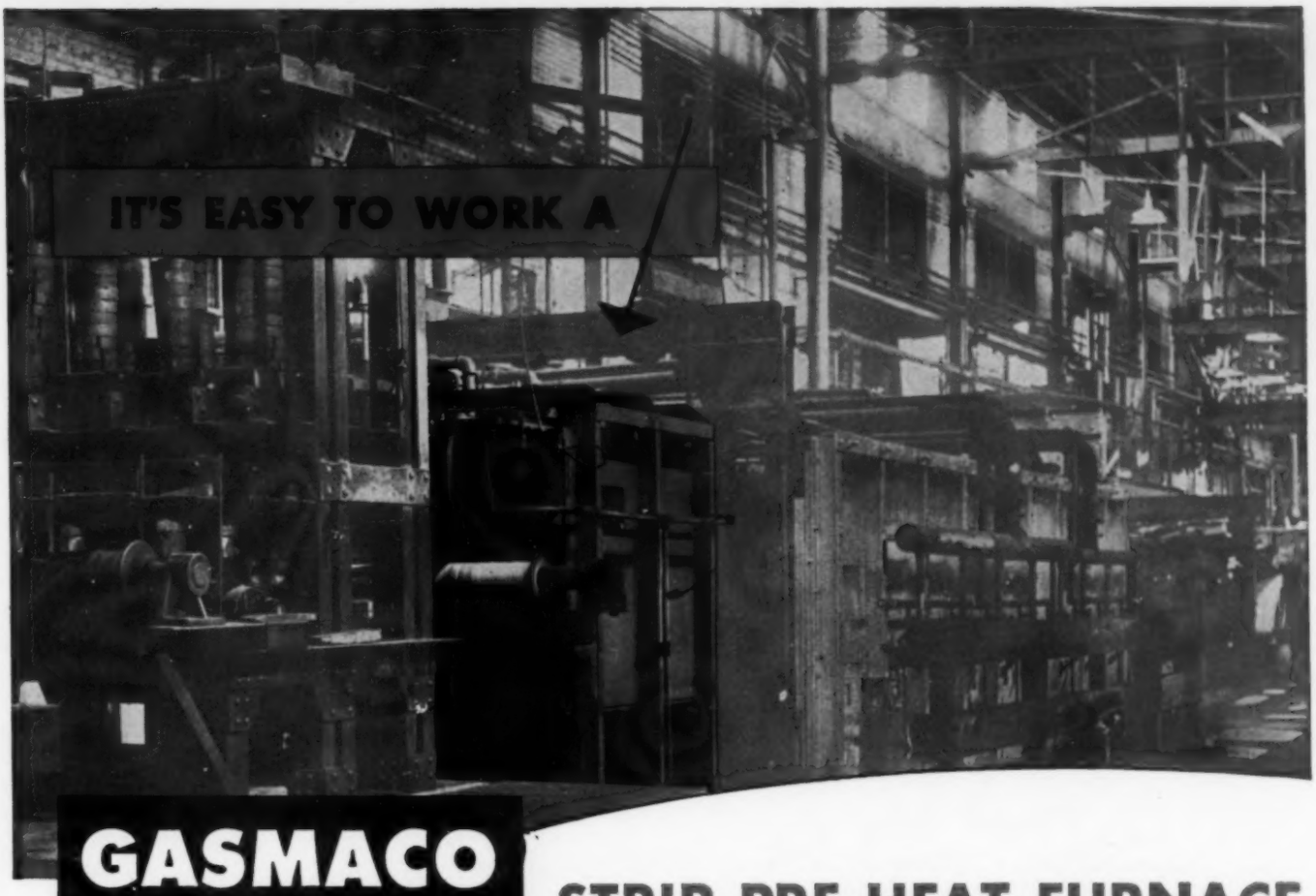
Smaller Foundations
Simpler connection with prime mover
Less floor space required
Reduced maintenance costs



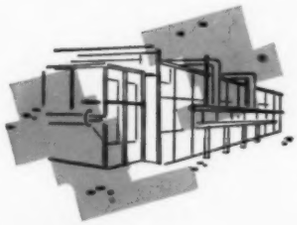
Write today for Data Sheets describing the Direct Flow Pump Series.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
21 PINE STREET
ALLENTOWN, PA.
Representatives in principal cities



GASMACO STRIP PRE-HEAT FURNACE INTO YOUR LINE



GASMACO pre-heat furnaces with HIGH HEAD HEATING are sized to a minimum . . . can usually be set in place without moving existing machinery.

Recent installation of a 6′ x 8′ furnace increased tonnage by 35% for an investment of $8,000.

With today's shortage of process capacity you can write off a GASMACO Pre-Heat Furnace in 3 months.

Let one of our experienced representatives discuss this latest GASMACO FURNACE and its application to your plant.

✓ *First with GASMACO for latest industrial furnace designs*

REPRESENTATIVES IN:

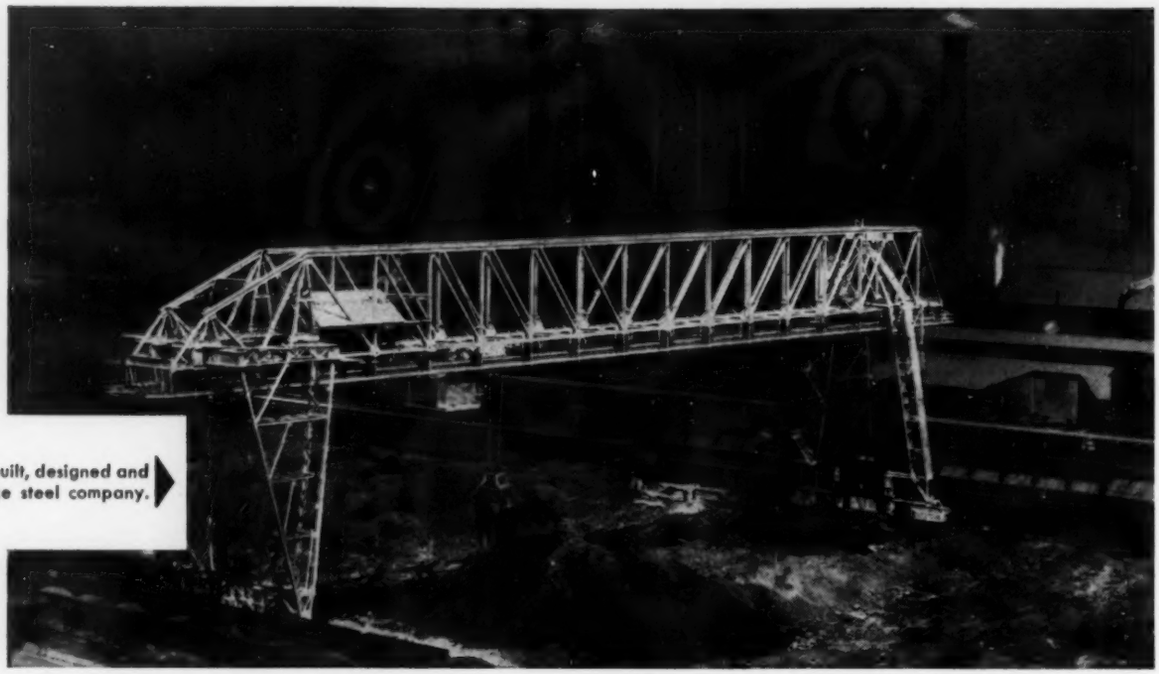
BIRMINGHAM • BOSTON • CHICAGO • DETROIT • HOUSTON • ST. LOUIS • LOS ANGELES • SEATTLE • SAN FRANCISCO

THE GAS MACHINERY COMPANY

16128 WATERLOO ROAD
CLEVELAND 10, OHIO

Designers • Fabricators • Erectors
Gas Plant Equipment and Industrial Furnaces

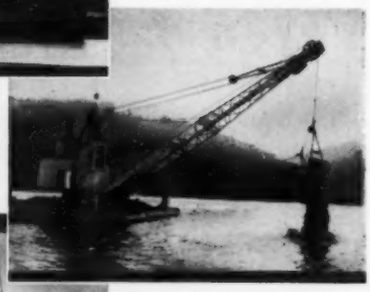
THE GAS MACHINERY CO. (Canada) Ltd.
HAMILTON, ONTARIO



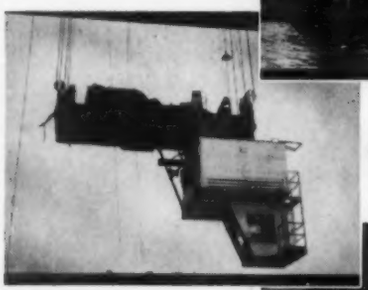
12-ton ore bridge, built, designed and installed for a large steel company.

DRAVO HEAVY MATERIALS-HANDLING EQUIPMENT ...CUSTOM BUILT FOR YOU!

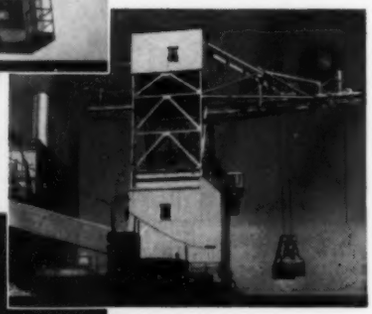
Travelling unloading towers built to handle imported iron ore at an Atlantic port.



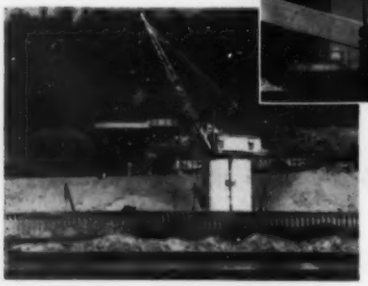
Whirler crane mounted on pontoon hull is used for dredging and general contract work.



Light-weight man trolley installation increased bridge handling capacity 60%.



Coal unloader designed and built for a large mid-western electric power company.



Stationary whirler crane designed and built to transfer coal from barges to hopper cars.

Over-all economical and safe performance is best obtained by using materials-handling equipment designed to suit your operating conditions. If you're planning a new materials-handling installation, we suggest an early "Round Table" session with Dravo engineers.

From actual experience over the past 60 years in building and installing the equipment shown here, valuable data is available in working out the features you want in your installation. This information, along with your own operating experience, can be used to create a design incorporating all the best features for easy maintenance, a high safety factor and simple, economical and satisfactory operation.

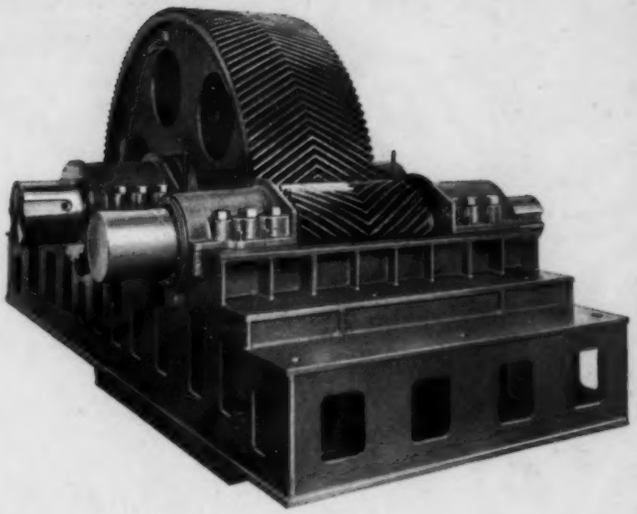
You can profit by taking advantage of this specialized "Round Table" service.

DRAVO

CORPORATION

NEVILLE ISLAND, PITTSBURGH 25, PENNSYLVANIA

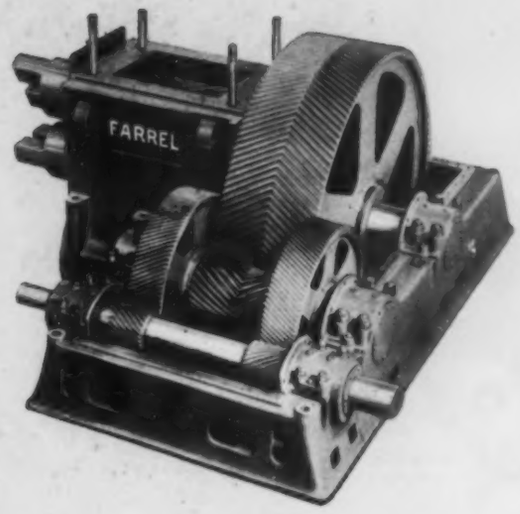
AIR CONDITIONING • BOILER AND POWER PLANTS
CRANE CAB COOLERS • DOCKS • INDUSTRIAL FOUNDATIONS
OPEN STEEL FLOORING • PUMP HOUSES AND INTAKES
SPACE HEATERS • WATER AND WASTE TREATMENT PLANTS
TOWBOATS AND BARGES



5500 HP

SINGLE REDUCTION UNIT

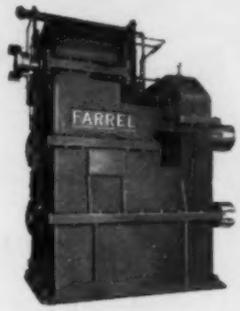
Herringbone-geared reduction unit designed to transmit power to a 134" three-high sheared plate mill, reducing motor speed from 375 to 70.35 RPM.



1000 HP

COMBINED DRIVE AND PINION STAND

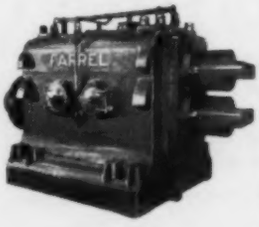
Designed to transmit power to a two-high cold brass rundown mill. The first reduction gears are opposed single helical and the second reduction gears and the mill pinions are Farrel-Sykes continuous tooth herringbone.



150 HP

TRIPLE REDUCTION UNIT

The three pairs of continuous tooth herringbone gears of this special tube mill drive provide a ratio of 113 to 1. A pinion unit is built as an integral part of the drive.



2000 HP

PINION STAND

21" pinion stand, designed to transmit power to a four-high aluminum sheet mill. The heat-treated, forged steel pinions are continuous tooth herringbone, generated by the Farrel-Sykes process.

TANDEM DRIVE

Transmits power from a single motor to six mills in tandem. Motor is connected to a herringbone gear reduction unit. Power is transmitted to the pinion stands through bevel gears mounted on a line shaft.

What do you need in a mill drive?

Do you need a single, double or triple reduction unit? Do you need a tandem drive, a pinion stand or perhaps a combination gear drive and pinion stand?

Whatever your requirements, no matter how unusual in design, size or capacity, Farrel will meet them. Each unit is individually engineered for the application.

Herringbone, single helical, or a combination of single and double helical gears may be furnished for gear drives. Mill pinions are usually herringbone type, although single helical pinions can be supplied. These gears and pinions are precision generated by the famous Farrel-Sykes process, assuring accuracy of tooth spacing, profile and helix angle, which results in high efficiency and smooth, quiet operation.

Send today for information on these designed-for-the-job mill drives. Or, if you prefer, a Farrel engineer will be glad to discuss your drive problems with you.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Fayetteville (N.C.), Los Angeles, Houston

FB-926

Farrel-Birmingham ®

5 OF A KIND...

The new A. E. C. project in Portsmouth, Ohio uses river borne coal to produce steam to generate electricity. Four identical Heyl & Patterson coal barge loaders . . . each with a capacity of 1200 TPH . . . take this coal from Ohio River barges. A fifth identical coal barge unloader has been placed in service at the Philip Sporn Plant, also located on the Ohio River.

These 5 Unloaders (2 were built for the Ohio Valley Electric Corp., 2 for the Indiana-Kentucky Electric Corp. and 1 for the Sporn Plant which is owned jointly by Ohio Power Co. and Appalachian Electric Power Co.) carry such standard H & P features as one man operation, automatic cable oilers, built-in service hoists and continuous reeving from large spools of cable.

Continuous reeving which saves many, many feet of valuable wire rope and precious man-hours, was an H & P "First."

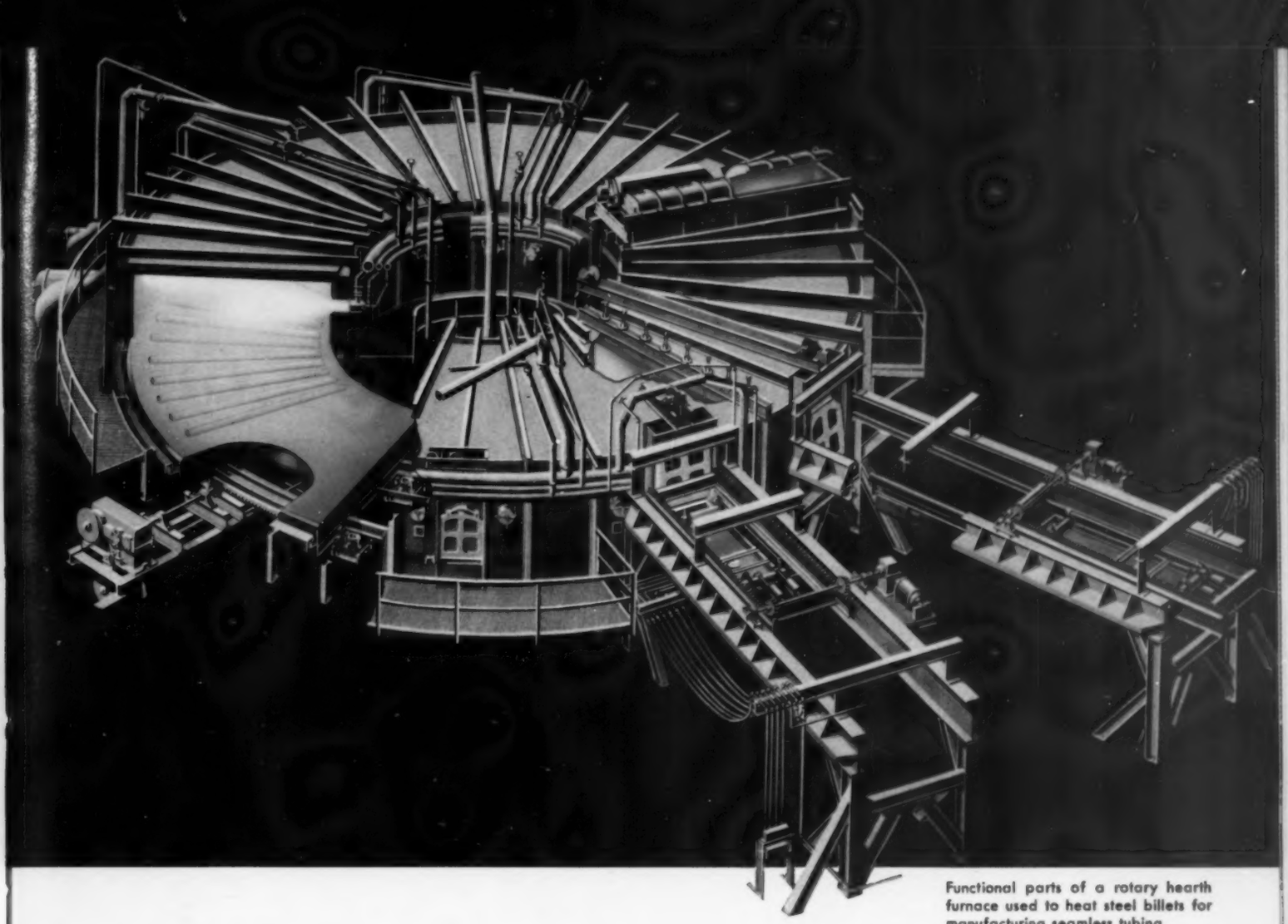
Optional H & P features on these 5 Unloaders include an enclosed manlift, space for storage and repair of spare bucket and a motor generator set for adjustable voltage control of hoist and trolley motions.

For more than fifty years Heyl & Patterson has been building Unloaders of various types and sizes for the handling of coal, ore, bauxite, sand, gravel, slag and other bulk materials from barges or ships. *When you have an unloading problem, phone or write for a Heyl & Patterson Engineer to consult with you.*

Heyl & Patterson
INC.

55 FORT PITT BLVD., PITTSBURGH 22, PA. • COurt 1-0750

- **Boat Loaders and Unloaders**
- **Cyclone Thickeners**
- **Coal Handling Equipment**
- **Thorsten Coal Samplers**
- **Coal Storage Bridges**
- **Rotary Car Dumpers**
- **Bradford Breakers**
- **Reineveld Centrifugal Dryers**



Functional parts of a rotary hearth furnace used to heat steel billets for manufacturing seamless tubing

Increase Productivity, Save Space, And Cut Fuel Costs With Salem-Brosius Rotary Hearth Furnaces

Most large rotary hearth furnaces in the world have been designed and built by Salem-Brosius or its licensees. Salem-Brosius developed the large rotary hearth furnace and continuously has improved its design and construction.

Salem-Brosius rotary hearth furnaces are in use today for production heating and heat treating carbon and alloy steel bars, slabs, round and square billets, shell stock and forging stock; and similar products in non-ferrous metals such as copper and brass.

The rotary type furnace saves floor space. Fuel efficiencies and economies are unequalled by any other type of industrial furnace. Heating is rapid and uniform. Charging and discharging is mechanical; and automaticity of control drastically cuts labor costs. A Salem-Brosius rotary hearth assures the minimum of maintenance and repair costs. These benefits spell higher furnace output, less downtime, lower production cost—and greater profit to you, the user.

The rotary hearth is but one of the many types of Salem-Brosius furnaces—furnaces of superior design and construction—furnaces that help improve your product and turn it out at a lower cost. If your plant modernization plans call for heating or heat treating furnaces of any kind, call on Salem-Brosius.

Other Salem-Brosius products include forging manipulators, furnace charging and discharging equipment, hot materials handling equipment, large gas main valves, blast furnace clay guns, and a long list of special machinery and auxiliary furnace equipment. A Salem-Brosius engineer will be glad to help you with problems involving any of this equipment, or any special equipment that must be tailored to your needs. Write to us.

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

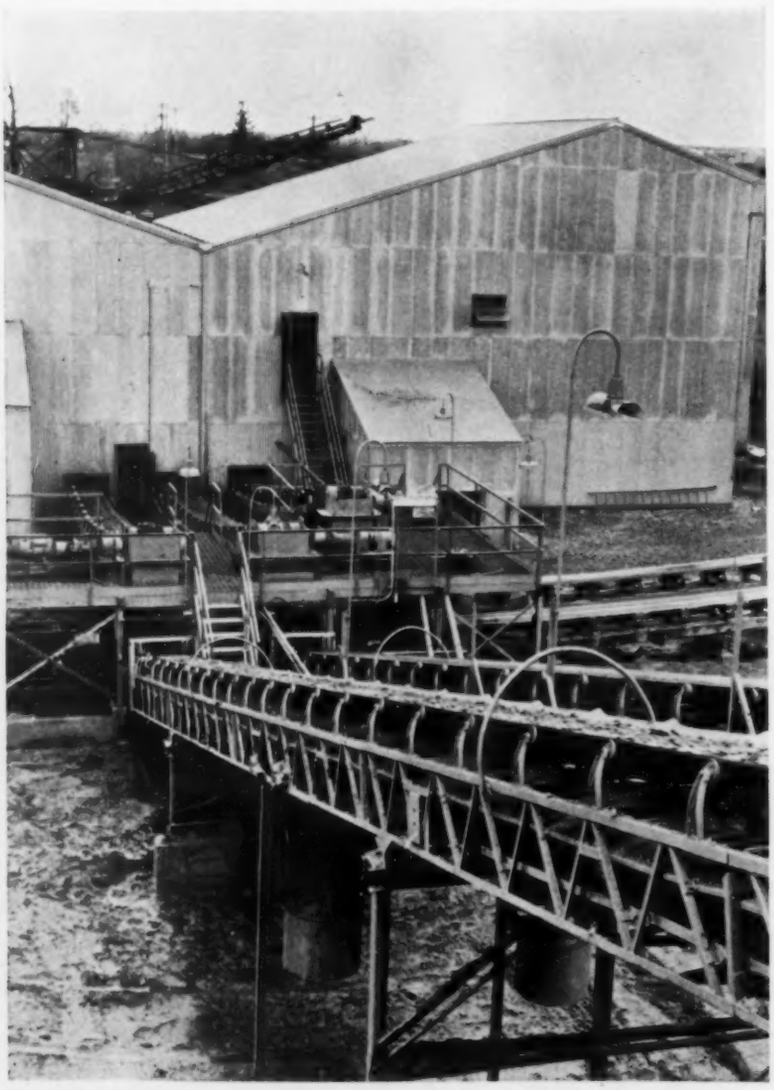
IN CANADA: SALEM ENGINEERING LTD. · 1525 BLOOR STREET WEST, TORONTO 9, ONTARIO

LOWER COST PER TON-MILE

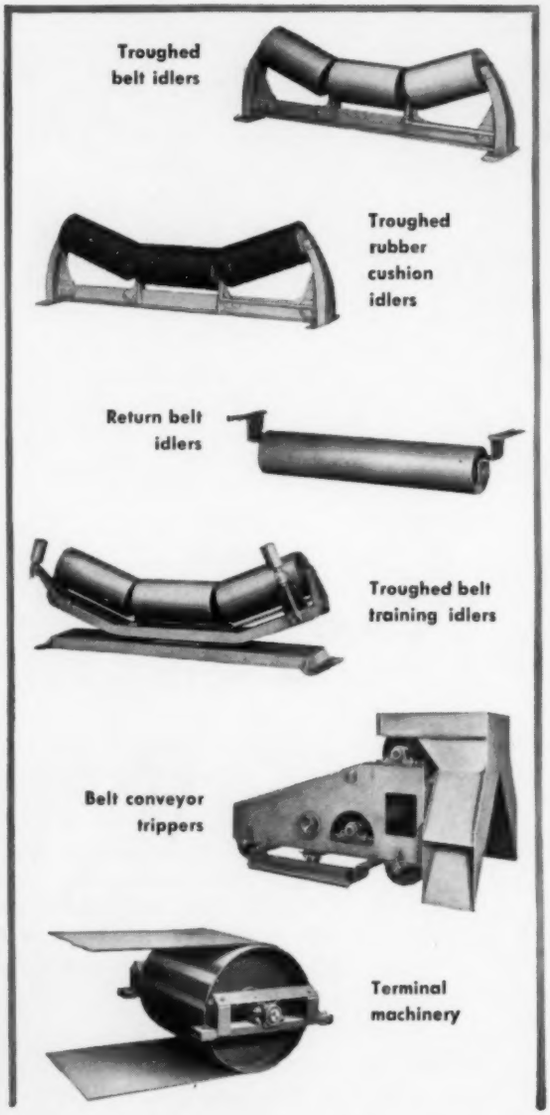
. . . yours with either a Link-Belt single belt conveyor or complete system

WHETHER you need a single belt conveyor or complete system, you'll find that Link-Belt engineering and equipment add up to lower cost per ton mile. Drawing from vast experience, our engineers can develop a system incorporating the most practical components from our complete line of quality idlers, trippers, drives, terminal machinery and other items. And if desired, we will handle erection.

Link-Belt has pioneered the development of belt conveyors for short or long hauls . . . indoor or outdoor service. To learn how this background can produce utmost economy per ton-mile in handling your bulk material, call your Link-Belt office.



Link-Belt 30-in. wide belt conveyors handling iron ore concentrate and tailings from washing plant to railroad and truck loading hoppers.



Link-Belt offers you one source for all equipment—including 500 idler sizes in 35 types . . . plus pulleys, drives, trippers and supports. Whatever the weight of loads, atmospheric factors or other operating conditions, you're assured of the easiest and most practical integration of belt conveyors into your overall system requirements.

LINK-BELT

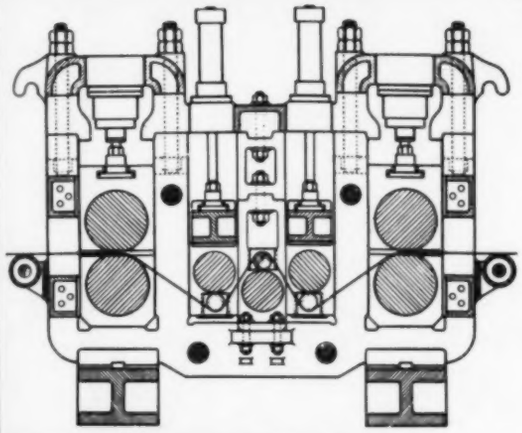
BELT CONVEYOR EQUIPMENT

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,952

F&Y TRIPLE SCALE BREAKER

Speeds Pickling with the New

"YOUNGSTOWN"



High Speed Continuous Strip Pickling Line

...Better Pickling with Less Acid and Lower Cost!

See our new, pull thru type, TRIPLE SCALE BREAKER, —a revolutionary improvement that eliminates the need for a Pinch Roll Stand in a modern Pickling Line. Investigate this and other new "YF&M" advantages. Whatever your pickling requirements,—complete new lines, revamping of existing lines, new tanks, rubber-covered rolls, Paralloy pinch rolls, any pickling line equipment,—get the benefit of our 70 years' experience. Consult "Youngstown" on how to speed up your pickling, cut acid consumption and make your operation more profitable.

features—

- Cone Type Payoff with Strip Opener.
- Triple Processor with Roller Leveller.
- Flash Welding and Mechanical Stitching.
- Pull-Thru Type Triple Scale Breaker.
- Single Cycle Up-Cut Shears.
- Heavy Duty Rubber Covered, Brick Lined Steel Tanks.
- Magnetic Loop Control for Acid Tanks.
- Fume Exhaust System —Roto Clone Scrubber.
- Automatic Control for Temperature and Acid Proportioning.
- Side Trimmer with Scrap Cutting or Balling
- Up-Coiler with Strip Oiling System.
- Entry and Exit Coil Conveyors.

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

GET EXTRA SUB-HEARTH

SAFETY AND LONGER LIFE

WITH KAISER PERICLASE D-S BRICK →

THIS superior brick has been *especially designed* to withstand sub-hearth conditions. Thus, it gives maximum protection against costly breakthroughs and provides longer sub-hearth life.

Steel men agree on the important properties for a sub-hearth brick. They are all found in Kaiser Periclase D-S Brick.

High MgO (more than 95%) is achieved through the use of pre-shrunk, accurately sized Periclase grains derived from sea-water magnesia. Absence of chrome eliminates the reduction of chromium oxide and damage to the refractory structure.

Low iron content minimizes refractory damage from alternate oxidation and reduction of iron oxide and other iron compounds. Absence of calcium oxide prevents damage caused by slaking during slow heat-ups or while furnace is idle.

With all its many advantages, Kaiser Periclase D-S Brick gives you the ultimate in sub-hearth safety and durability—*yet costs no more!*

Call or write Kaiser Chemicals Division, *Kaiser Aluminum & Chemical Sales, Inc. Regional Sales Offices: 1924 Broadway,* OAKLAND *12, Calif. . . . 3 Gateway Center,* PITTSBURGH, *Pa. . . . 518 Calumet Building, 5231 Hohman Ave., Hammond, Indiana* (CHICAGO).

For the ultimate in steel furnace refractories

Kaiser PERICLASE Brick for the Steel Industry:
• Kaiser Periclase D-S Brick • Kaiser Periclase Chrome Brick • Kaiser Chrome Periclase Brick
Now available! A companion mortar for Kaiser D-S Brick. High purity periclase composition and maximum workability.
INSTALLATION ADVICE ON REQUEST

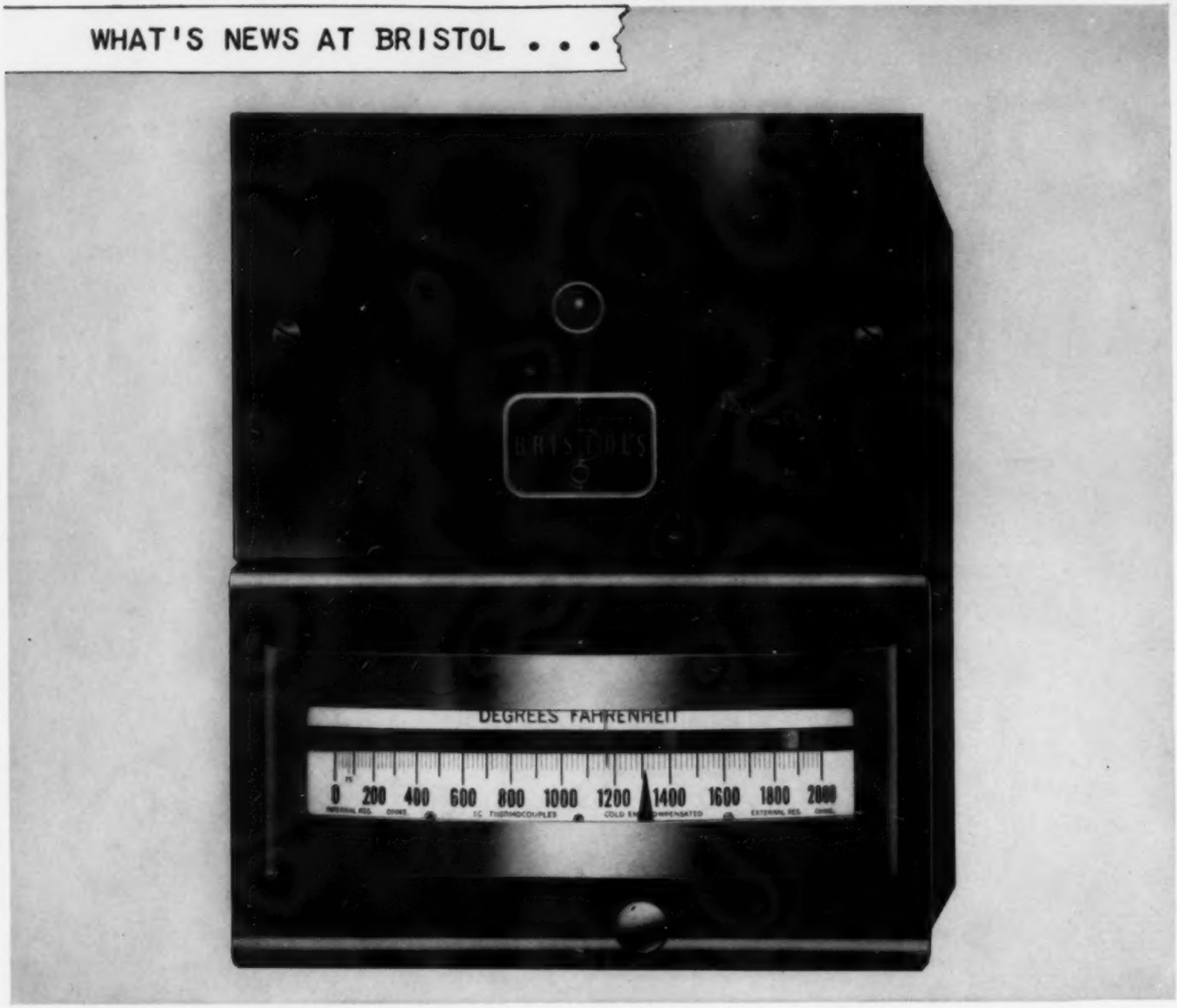
. . . . think of Kaiser Chemicals

Pioneers in Modern Basic Refractories

CHEMICALS KAISER REFRACTORIES

Refractory Brick, Ramming Materials, Castables & Mortars • Magnesite • Periclase • Deadburned Dolomite

WHAT'S NEWS AT BRISTOL . . .



Thyratron-operated relay gives you closer control with this Bristol temperature controller

An extremely minute change in the measured quantity (less than 0.003 in. on the scale) is all it takes to close or open the Thyratron-operated relay of Bristol Series 536 indicating Free-Vane® Electronic Pyrometer Controllers.

This positive trigger control action makes it impossible for the relay to flutter or chatter, thus reducing wear on the relay. Other features of this extremely stable, rugged and sensitive instrument include:

MILLIVOLTMETER MECHANISM for greater accuracy with a sensitivity of 15 ohms per millivolt.

NO DRIFT IN SET POINT with changes in ambient temperature, line voltage, or tube characteristics.

EXTRA-WIDE SCALE for close, quick, easy reading.

EASY INSTALLATION AND SERVICING with plug-in components. No routine adjustments needed.

AVAILABLE AS THERMOCOUPLE and radiation pyrometers in ranges up to 4000F for L, H, LH, LOH and LNH control, and for L and H with proportional input.

Write for Bulletin P1248. The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. 5 39

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BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

18 Years on the Job

. . . *still going strong*

. . . a pleasing record but not unique for users of Morgoil Bearings. Long life, of course, is a desirable attribute. But perhaps more important to you is the accuracy of rolling that Morgoils permit . . . the savings in power . . . the almost complete freedom from maintenance costs.

Whatever you are looking for in a roll neck bearing you will find it in Morgoil—the preferred bearing of the world's largest producers.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - EJECTORS
REGENERATIVE FURNACE CONTROL

English Representative:
International Construction Company, Ltd.
56 Kingsway, London, W. C. 2, England
MB-24

48"-72 Morgoil Bearings operating in 25½ and 52x90, 4 high hot strip mill at Granite City Steel Co., Granite City, Illinois.

MORGOIL
ROLL NECK BEARINGS

TRANTINYL

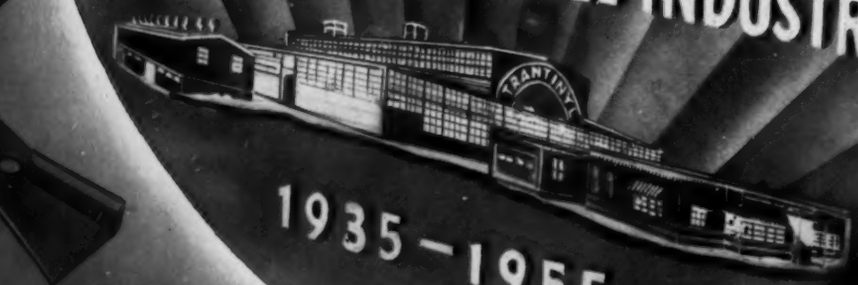
GUIDES THE STEEL INDUSTRY

YOUNGSTOWN ALLOY CASTING CORPORATION

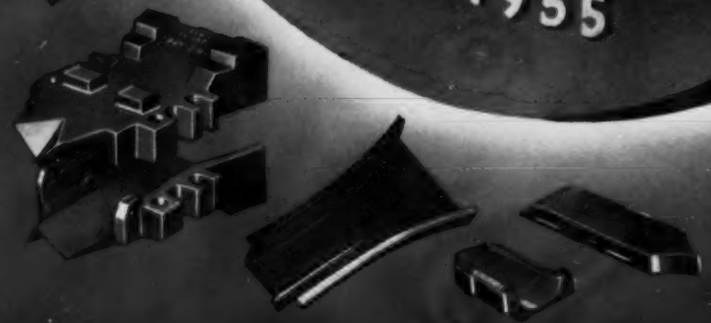
CELEBRATING

20 YEARS

OF SERVICE TO THE STEEL INDUSTRY



1935—1955



20-Year-Users find that "TRANTINYL" Alloy Steels have no equal—in tonnage rolled over one set of guides.

ROLLING MILLS:
bar, hoop, strip, shape mill guides; and rollers

SEAMLESS TUBE MILLS:
guide shoes, rolling mill plugs and rolls, piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing rolls, tool holders, etc.

STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

Youngstown Alloy Casting Corporation

Youngstown, Ohio

SEVENTY-SIX 10-hp d-c approach table motors for McLouth reversing roughing mill.

With the help of G-E system-engineered electrical equipment . . .

McLouth Steel improves hot strip production through increased flexibility and ease of maintenance

The new 60-inch hot strip mill at McLouth Steel Corporation's expanded Trenton, Michigan, plant utilizes individual d-c motors for each roll of roughing mill front and rear tables, as well as roughing and finishing mill approach tables, and pumpless rectifiers in unit substation arrangement to supply power to individual finishing stand d-c motors. These unique applications result in greatly increased flexibility and ease of maintenance.

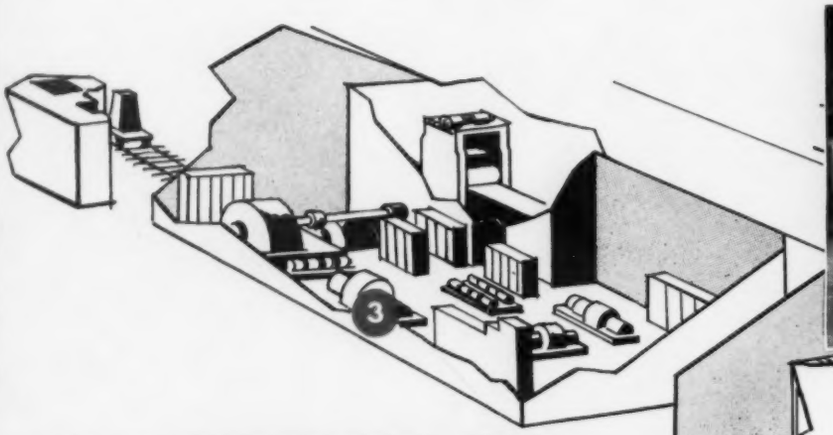
In addition McLouth engineers predict savings of $60,000 per year in lubrication costs alone by switching to individual roll drive d-c motors. This application of individual d-c motors eliminates the need for reduction and bevel gears and line shaft and therefore minimizes maintenance and periods of unscheduled downtime. 659-108

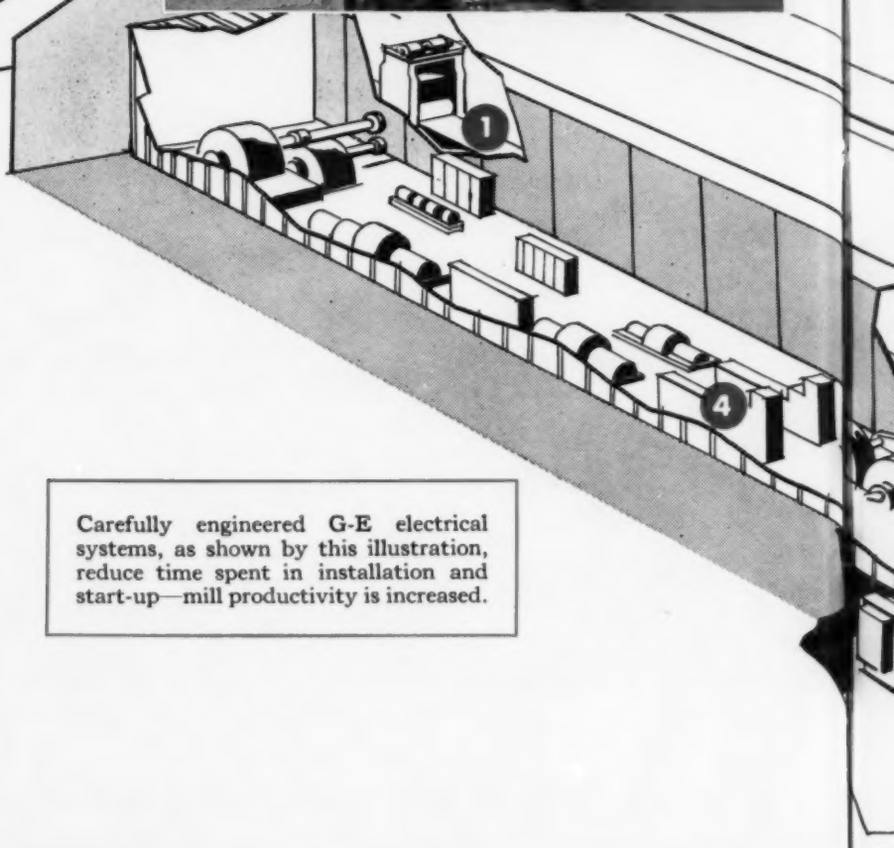
SEE ELECTRICAL SYSTEM LAYOUT ▶

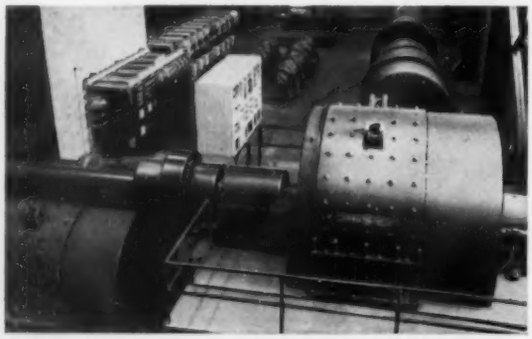
GENERAL ELECTRIC

How General Electric System Engineering

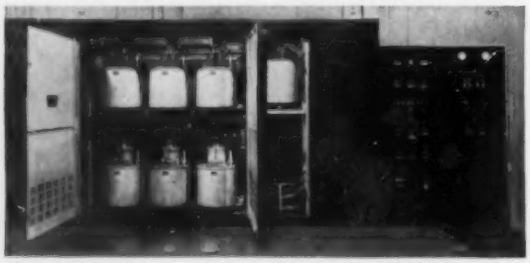
1 146 INDIVIDUAL ROLL MOTORS driving tables result in flexibility of maintenance, decreased operating costs. Engineered design integrates all table sections.







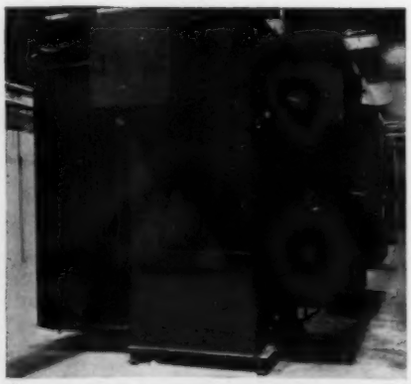
3 MAIN DRIVE for the blooming and slabbing mill is a 6000-hp d-c twin motor backed up by auxiliary m-g sets, d-c switchgear and duplex switchboard.



4 THIS SECTION of 4000-kw stand 3 rectifier features new ignitron stainless steel tanks and dual ignitors for dependable service—low maintenance.

Carefully engineered G-E electrical systems, as shown by this illustration, reduce time spent in installation and start-up—mill productivity is increased.

5 ECONOMY OF INSTALLATION for the hot strip mill is achieved by unit substation construction and close location of the rectifier equipment with respect to the stand motor drives.

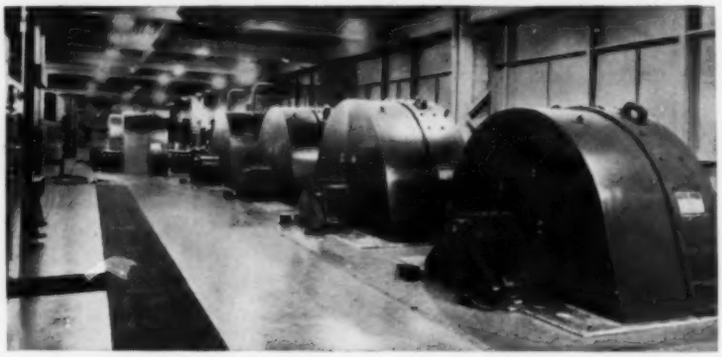


6 EACH STAND'S regulating autotransformer allows operation over wide speed range by individual stand voltage control.

7 SYSTEM ENGINEERING eases motor room operation by centralizing master control functions for mill stands in this duplex control switchboard.

Helped McLouth Increase Productivity

2 **A TOTAL OF 28,500-HP** supplies the "muscle" for the 60-inch 6-stand hot strip finishing mill. Motor room stand 1 to 5 motors are rated 5,000-hp. Stand 6 motor (on right) furnishes 3500-hp.

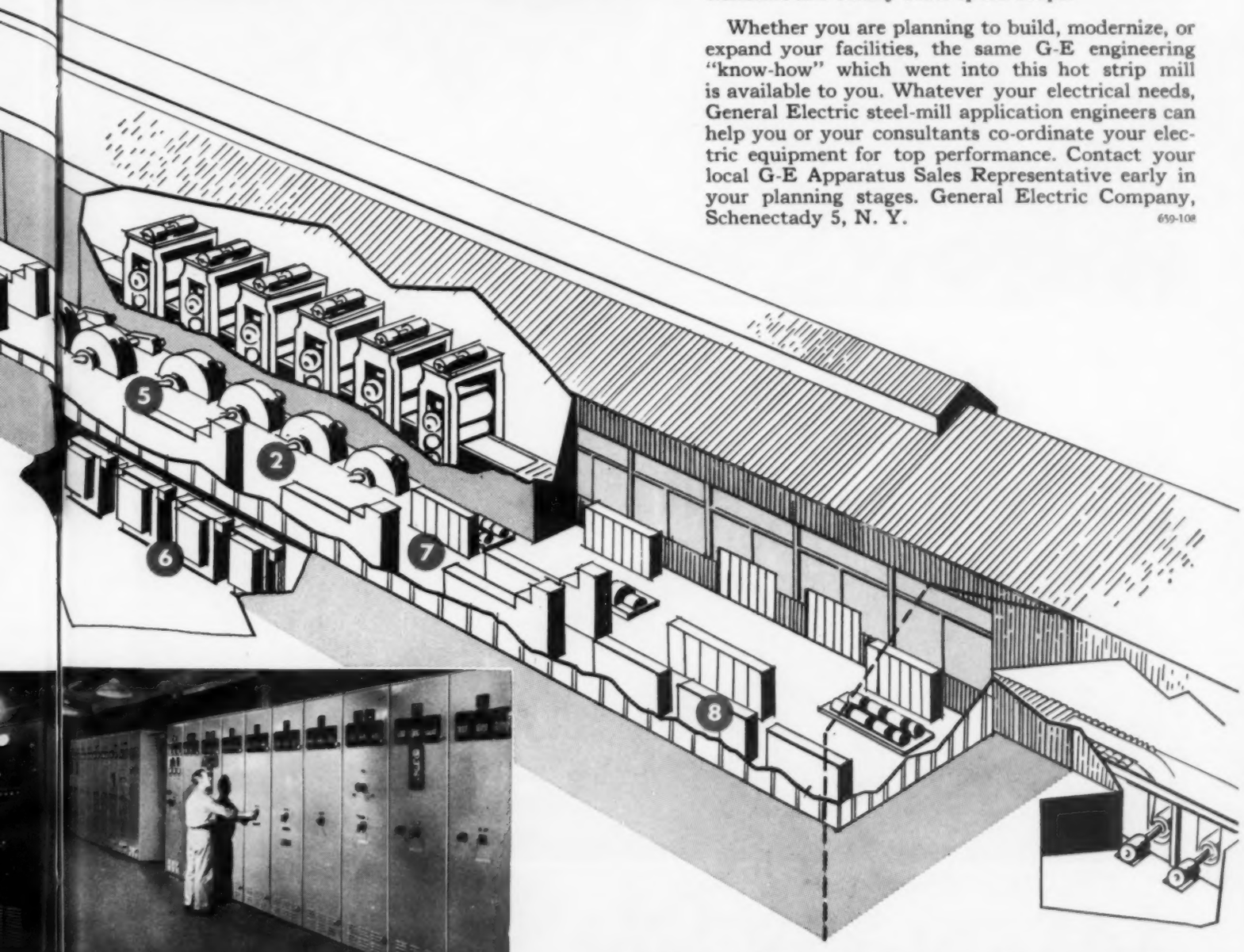


EXCELLENT EXAMPLE OF STEEL MILL PROGRESS

McLouth's new hot strip mill is an excellent example of the progress made in the application of electrical equipment to semi-continuous hot strip mills. This new plant, in full production 15 months from date of order, will produce up to one million tons of strip annually.

G-E designed individual-rectifier control gives the mill greater flexibility and simplicity of operation, plus a higher percentage of "on-gage" strip. G-E d-c drive motors are specially designed to withstand frequently repeated heavy loads with minimum transient and steady state speed drops.

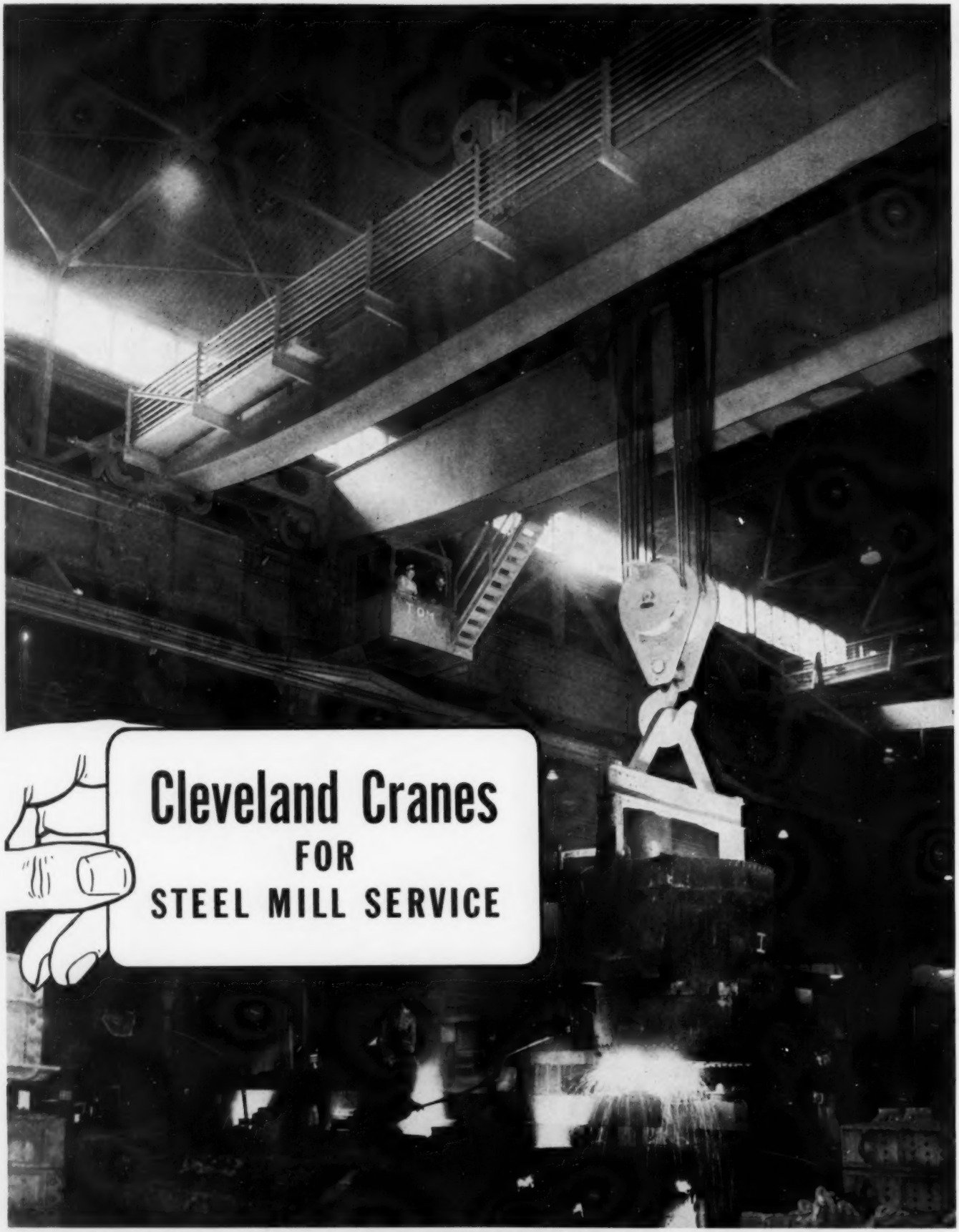
Whether you are planning to build, modernize, or expand your facilities, the same G-E engineering "know-how" which went into this hot strip mill is available to you. Whatever your electrical needs, General Electric steel-mill application engineers can help you or your consultants co-ordinate your electric equipment for top performance. Contact your local G-E Apparatus Sales Representative early in your planning stages. General Electric Company, Schenectady 5, N. Y. 659-108



8 **ALL INCOMING POWER** flows through this a-c metal-clad switchgear. Reliable magne-blast air circuit breakers provide service entrance and feeder protection.

Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

ANNOUNCEMENTS of steel expansion projects continue apace, and now total an annual capacity of 6,494,000 tons, with United States Steel and Bethlehem yet to be heard from. The grapevine has U. S. Steel spending $150,000,000 at Fairless Works for coke ovens, one blast furnace, four open hearth furnaces and some finishing equipment; an unannounced amount in the Chicago district; and $400,000,000 in its other plants.

Steelmakers now talk of an annual capacity of at least 140,000,000 tons by 1960.

▲

GROSS national product, industrial production, personal income, employment, personal savings, corporate earnings, department store sales — all at boom levels.

Now if we could just combine this with the old dollars that would buy something — but which we didn't have then.

▲

THE oxygen steelmaking process, now in use at Dominion Foundries and Steel, Ltd. and McLouth Steel Corp. and slated for installation by Jones & Laughlin Steel Corp., gained another notch with the announcement by Wheeling Steel Corp. that it will install two oxygen converters, with an annual capacity of 270,000 tons, at its Steubenville plant.

▲

NATIONAL Safety News says: If life were lived backwards, from old age to youth, there'd be a lot more juvenile delinquents.

▲

THE demand for coke, both for domestic use and for export, has again reactivated the beehive ovens. United States Steel Corp. is rehabilitating 500 ovens, Pittsburgh Consolidation Coal Co. 300 ovens, and Hillman Coal and Coke is increasing its beehive operations.

▲

AN observant correspondent says that women come in four sizes: thin, average, plump and "Get a load of that!"

▲

THE merger of the American Federation of Labor and the Congress of Industrial Organizations brings together about 15,000,000 union members — some 22 per cent of the country's total labor force.

As the size of labor organizations increases, and as evidence of racketeering and mismanagement in unions is continually uncovered, it becomes more and more obvious that some degree of government regulation is needed.

Business and industry are regulated by laws designed to protect the public good. Unionism can do the public just as much harm, and mismanaged, can do grave injustice to its members as well. Let's not make it a sacred cow.

▲

THE Pacific Northwest will soon benefit by the availability of natural gas. Pipe lines from Colorado and New Mexico, and from the Peace River region in Canada, will carry some 640,000,000 cu ft per day. This will be a great advantage for industries using large quantities of fuel.

▲

AN authoritative source tells us that the real reason behind the growth of sales taxes in recent years is to find a use for pennies.

▲

THE shortage of engineers seems to get worse and worse, both for new graduates and for experienced men — and there seems to be little relief in sight for the near future. The problem reaches back into the high schools, where the so-called modern curricula have allowed science and mathematics to languish. Various organizations are working to encourage boys to go into engineering, but any results from this are some years away.

Immediate relief apparently must come through better use of the presently available supply, through using men over retirement age and taking on available men now considered over age, through greater use of non-technical graduates where technical training is not absolutely essential, and through training of high school graduates by industry and night school.

▲

ELECTRIC power generation is regularly exceeding 10,000,000,000 kwhr per week, a figure never attained until early this year. It is believed that 11,500,000,000 kwhr may be reached before 1955 is over.

▲

AN old friend of ours warns us about experts. He says an "ex" is a has-been and a "spurt" is a drip under pressure.

▲

THERE were 61,334,000 motor vehicles registered in the United States in 1954, of which 50,954,000 were passenger cars owned by 35,000,000 families (71 per cent of the total families).

The United States produces 70 per cent of the world's passenger cars.

▲

EVEN though we're a year older each time we say it, it still gives a warming thrill to wish every one of you a MERRY CHRISTMAS and a HAPPY NEW YEAR.

MUSCLES

HAGAN

POWER POSITIONERS IN *FULL* RANGE OF SIZES!

6" x 10" Hagan Power Positioners operating inlet louvers to the forced draft fans for boilers of large power plant. (midwest climate)

10" x 30" counterweighted Hagan Power Positioner for 2500 pound slide type damper.

8" x 25" Hagan Power Positioner operating 54" butterfly valve, controlling flow of blast furnace gas to boiler. (Outdoor installation, note steam tracer lines)

FOR INDUSTRY

Hagan Power Positioners are rendering dependable, accurate service under the most severe operating conditions. These rugged, double acting units assure plenty of power, and are meeting high standards of accuracy for valve, damper and lever operating applications.

Low piston leakage, low piston friction and modest cost make Hagan Precision Positioners an economical buy.

CHECK THESE MANY OUTSTANDING FEATURES:

ACCURATE—piston takes a positive position for every incoming signal. Repeatability—1%.

HIGH SPEED—90% stroke in as little as 1.0 second.

FLEXIBLE—positioning is normally linear with signal pressure, but any desired relationship may be obtained by shaping the feedback cam.

INPUT SIGNAL RANGES—complete selection of ranges—3-15, 0-30, 0-60; others available.

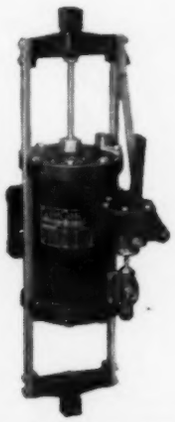
RUGGED CONSTRUCTION—insures dependable, long, trouble-free life.

FULL RANGE OF SIZES—4" to 12" bore—5" to 48" stroke. Full power for any need.

ACCESSORIES—Manual Operators—piston air locks—limit switches and many others.

4" x 5" HAGAN POWER POSITIONER

Stall torque—400 lb ft.*
90% full stroke—1 sec.
Specification Sheet TP-245

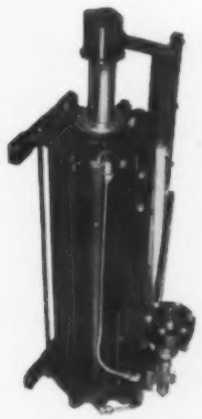


5" x 10" HAGAN POWER POSITIONER

Stall thrust—1950 lbs.*
90% full stroke—1.8 sec.
Specification Sheet TP-1510

8" x 14" HAGAN POWER POSITIONER

Stall torque—4600 lb ft.*
90% full stroke—2.5 sec.
Specification Sheet TP-2814



12" x 48" HAGAN POWER POSITIONER

Stall thrust—11,000 lbs.*
90% full stroke—6 sec.
Specification Sheet TP1100

*With 100 psi power air

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

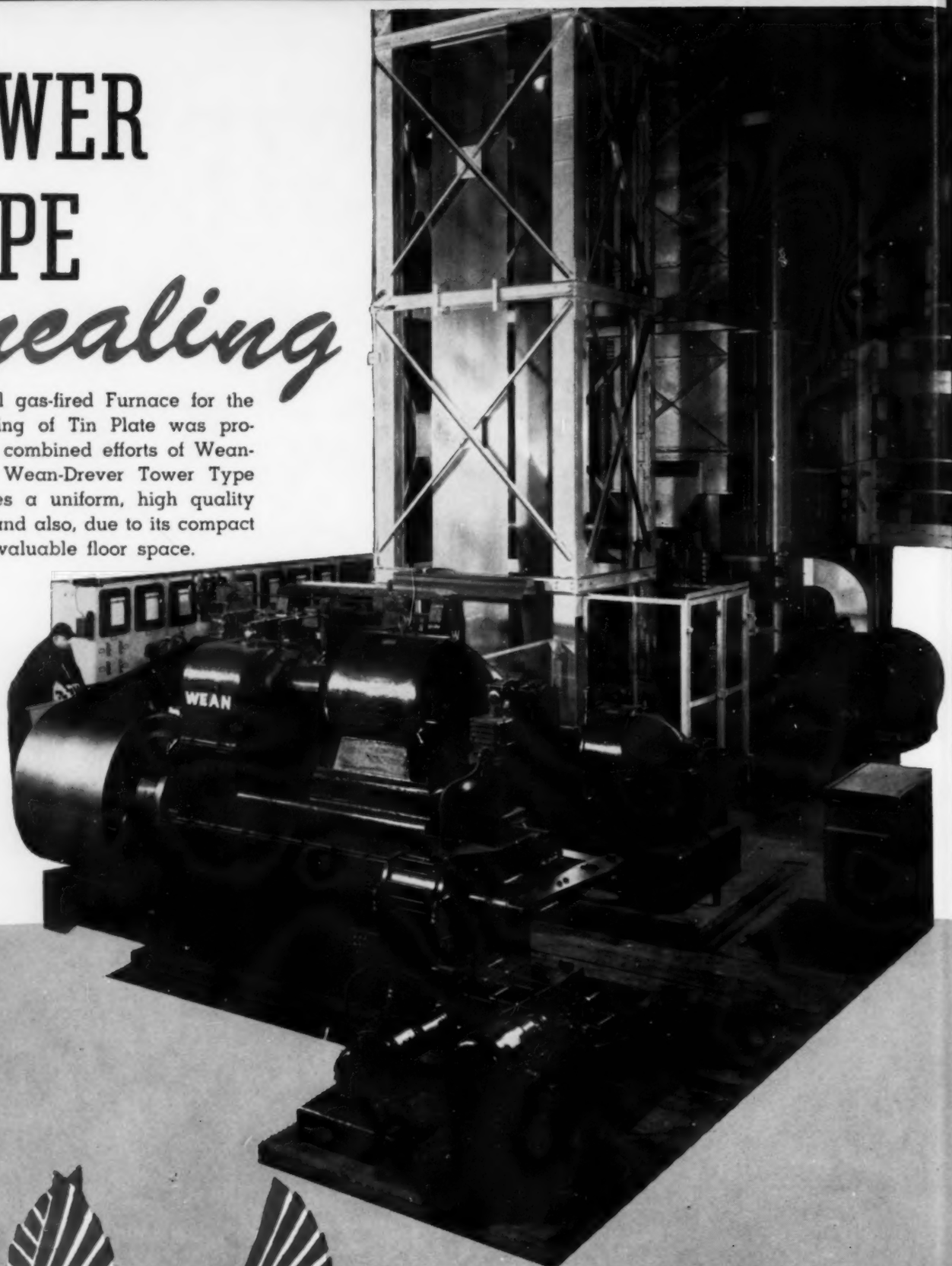
HAGAN BUILDING • PITTSBURGH 30, PENNSYLVANIA

Metallurgical Furnace Control Systems • Boiler Combustion Control Systems • Ring Balance Flow and Pressure Instruments • Control Systems for Aeronautical and Automotive Testing Facilities

TOWER TYPE *Annealing*

The first successful gas-fired Furnace for the continuous annealing of Tin Plate was produced through the combined efforts of Wean-Drever engineers. Wean-Drever Tower Type Annealing produces a uniform, high quality annealed product and also, due to its compact design, conserves valuable floor space.

Thus Wean engineers again have proven their leadership as Specialists in Sheet, Tin and Strip Mill Equipment.



by The

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Iron and Steel ENGINEER

DECEMBER, 1955 VOLUME XXXII NUMBER XII

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

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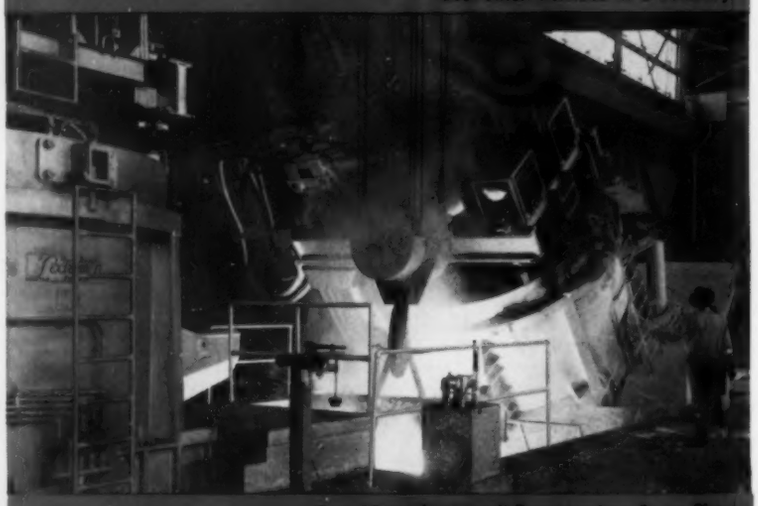
Indexed by Engineering Index and by Industrial Arts Index.

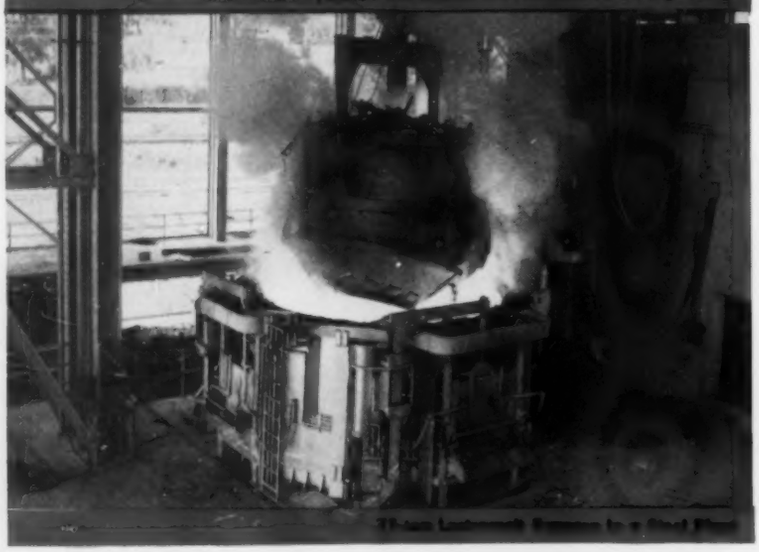
Single Copy Foreign Prepaid $2.00 (U. S. funds) Single Copy $1.50
Subscription price in U. S. and Canada (U. S. funds)..... $ 7.50 per year
Subscription price in foreign countries (U. S. funds)..... $10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1870281 LICENSE NO. 120

Lectromelt Furnace in a Foundry



Two 30 ton Lectromelt Furnaces in a Forge Shop



75-ton Lectromelt Furnace in a Steel Plant

Melting goes fast and smoothly with *Lectromelt** furnaces!

Labor-Saving Top Charging Lets a Lectromelt Furnace Get to Work Fast

4% more tonnage per heat, 30% more heats per month, 35% more average monthly output—these are figures reported by a steel company operating several Lectromelt Furnaces. Lectromelt's system of top-charging gets scrap into the furnace fast, saving many man-hours and producing more metal.

With Lectromelt Furnaces, you can crowd on the power, greatly increasing their output. They are built husky to withstand this push for production. Lectromelt Furnaces are durable and dependable.

For Melting, Refining, Smelting and Reduction

Lectromelt Furnaces have been proved by years of service in the metallurgical and chemical industries. Our engineers will advise you on these processes and tailor the entire installation to suit your needs.

Catalog No. 9 describes melting furnaces. Catalog No. 105 describes those for smelting. For a copy of either book, write Pittsburgh Lectromelt Furnace Corporation, 310 32nd Street, Pittsburgh 30, Pa.

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*REG. T. M. U. S. PAT. OFF

MOORE RAPID

WHEN YOU MELT... *Lectromelt*

High Speed Rod Rolling at Continental Steel Corp.

By DON C. HORSMAN

Assistant General Superintendent, Continental Steel Corp., Kokomo, Ind.

. . . . indicative of the methods which have been used to increase production are the features built into the new mills such as the one described in this paper . . . . production gain is accomplished through multi-strand rolling, higher speeds and larger bundles . . . . these features in turn require careful design, more extensive equipment coordination, and increased mechanical handling of product . . . .

▲ THE purpose of this paper is to discuss the machinery and equipment of a new high speed rod mill which Continental Steel Corp., Kokomo, Ind., installed and placed in operation on May 4, 1953. Portions of the mill had been subjected to test runs as the installation of the various component parts made them available. On February 12, 1953, nine billets, each 6 ft long and 2½ in. square, were heated in an auxiliary furnace and rolled through the roughing mills to produce sections finished on No. 8 stand of approximately ⅞ in. square. On February 27, 1953, four billets, 15 ft long, and 13 billets, 30 ft long, each 2½-in. square, were rolled through the first 16 passes to produce $^{13}/_{32}$-in. rods.

Figure 1 — The new high speed rod mill at Continental Steel Corp., Kokomo, Ind., produces 0.218 to 0.672 in. rods at rates up to over three miles of rod per minute.

Excavations, foundations and construction of the buildings were contracted to outside firms. All electrical installations including conduit were installed and tested by plant personnel, with supervisory assistance from the equipment suppliers. All machinery, equipment and piping was also installed by plant personnel with supervisory assistance from the mill builder. Some of the pertinent data relative to the construction of the mill include the use of 15,000 cu yd of concrete, 1250 tons of steelwork, 100 miles of electrical wiring, and over 20 miles of electrical conduit; this to provide the location and servicing of the electrical and mechanical equipment of the mill. A 25-ton, electric overhead traveling crane with a 5-ton auxiliary hoist spans the main mill building, which measures 300 ft x 94 ft. The motor room is 225 ft x 60 ft and is spanned by a like crane, except that this crane has floor operated controls.

The mill's principal features are generally similar to the new rod mill placed in operation at Aliquippa, Pa., a little over a year previous to initial operations at Kokomo.

In installing this mill, every precaution was taken to provide for production of the highest quality of rods possible, and a coil weight is produced that will allow

efficient operations in subsequent processing. The mill embodies in its design and construction the latest known electrical and mechanical developments, and utilizes automatic mechanisms to perform a great many functions in the process of rolling and handling rods.

Much consideration was given to the fact that in recent years the requirements for wire and rods have become increasingly more exacting and more difficult to attain as manufacturers have sought ways to decrease the cost of their products by forming or stamping many parts from wire that were formerly machined from steel bars. These demands now require wire of a higher quality to withstand these forming operations. Surface condition becomes extremely important to satisfy the plating requirements of today's market; seams and internal weaknesses must be eliminated to provide good cold forming qualities; and requirements for uniformity of temper dictate that size variations and stretching of the bar be reduced to a minimum. All of these factors and many more were considered in selecting and designing this mill for Continental Steel Corp. to produce high quality rods in coil weights up to 600 lb.

Most of the steel rolled on this mill is in the low carbon range with almost an even distribution between rimmed steel and semi-killed steel. A complete range of sizes from $\frac{7}{32}$ up to $\frac{43}{64}$ in. diam is now rolled, with provisions for future rolling up to $1\frac{1}{8}$-in. diam rounds or equivalent cross sections. About 90 per cent of the product is being drawn in the wire mill, the majority of which is scheduled for manufacturers' wire, with relatively heavy concentrations of extra clean, smooth, bright wire for plating purposes and bright cold heading, forging or roll threading quality. Large tonnages are also further processed by Continental Steel Corp. mills for galvanized wire, nails, barbed wire, many types of farm fence, ornamental and chain link industrial fencing and various specialty products.

GENERAL CONSIDERATIONS

Three-strand rolling is the normal practice and 22 mill stands are used in the full mill layout. Both laying and pouring reels are provided for coiling the hot rods. Six laying reels handle rods up to $\frac{3}{8}$-in. diam and three pouring reels are used to coil $\frac{23}{64}$-in. diam and larger rods. Three additional pouring reels are now on order to increase the tonnage potential on large rods. A $2\frac{1}{2}$-in. square billet is used for all sizes of rods so that the number of stands in operation is determined by the size of the finished rod. Four rod sizes from 0.218 to 0.243 in. are finished on stand No. 22. Four sizes of rounds between 0.250 and 0.281 in. are rolled from stand No. 20. Seven rod sizes between 0.296 and 0.375 in. are finished on No. 18 stand.

Rods coiled in the pouring reels are finished either on stand No. 15 or stand No. 16. Four sizes of rounds between 0.350 and 0.391 in. are finished on stand No. 16. Four rod sizes between 0.406 and 0.500 in. are rolled from stand No. 15 with stand No. 14 blanked. Six rod sizes between 0.531 and 0.672 in. are finished on No. 15 stand with stands No. 9, 10 and 13 blanked.

In order to roll three bars simultaneously and still maintain extreme accuracy, special roll turning tools were provided and extreme care was exercised in selecting electrical and mechanical features to be used in the mill. All roll necks are equipped with anti-friction bearings. Roller bearings are used to take radial loads and double row angular contact ball bearing assemblies are used to withstand thrust and to maintain proper vertical alinement on the intermediate and finishing trains. Guides are carefully ground or precision cast to exact template contours and roller twisters are provided to eliminate scratching of the rods, which frequently occurred when friction guides alone were used. Provisions for both top and bottom roll adjustment are provided and all adjustments are made from the operating side of the mill. Each stand is equipped with hydraulic roll balances, which keep the rolls separated under extreme pressure and eliminate the usual spring in roll assemblies which would otherwise be encountered when bars enter the rolls. The finest precision machined gears are employed throughout the mill construction, and precision fit anti-friction bearings insure the proper alinement of these gears. In addition to making every provision for building a precision mill, much thought and effort was expended in incorporating a quality of ruggedness which would insure many years of successful operation.

ELECTRICAL EQUIPMENT

Seven 600-volt, d-c drive motors with wide speed variation combine to provide 7100 hp for driving the mill. Regulating exciters are supplied for the auxiliary field of each motor, to minimize the impact speed drop which would otherwise cause the motors to become out of balance with each other. In addition, special characteristics were built into these motors to maintain steady speed regulation over the full range. Two 2500-kw, 600-volt generators supply the adjustable voltage d-c power for these motors. Close voltage regulation of the main power bus is obtained by the interaction of the various

Figure 2 — The $2\frac{1}{2}$-in. square billets are being started into the mill. Three billets are rolled simultaneously on this modern mill.

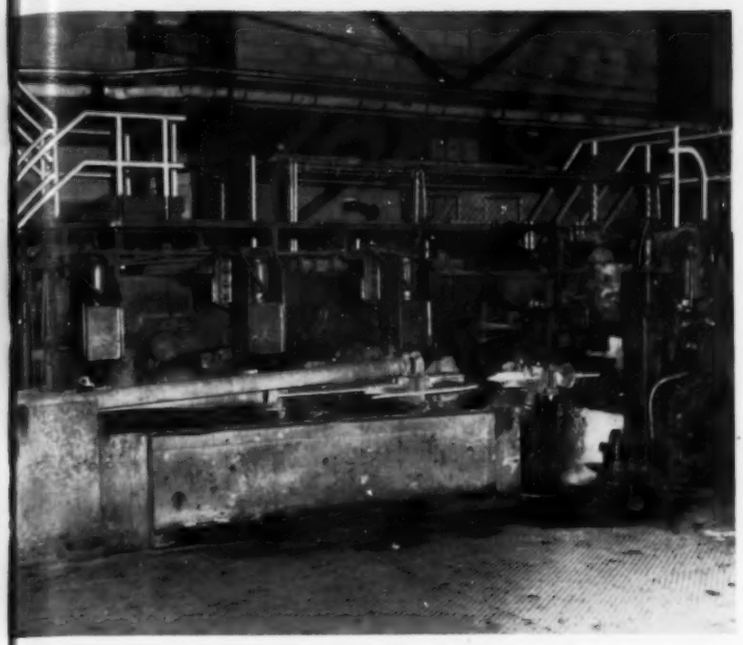


Figure 3 — This unique triple-strand flying shear automatically crops the leading end from each bar as it is rolled. Electric eyes control its operation.

fields of the regulating exciter. These fields provide reference to a set master voltage, balance, and stabilization of the voltage supply to the drive motors. All of these mill motors, except the 2000-hp finishing motor, but including the motor-generator sets, together with scores of automatic boards for auxiliary equipment, are contained in a pressurized motor room, that is continuously supplied with cleaned and conditioned air from special air cleaners.

For the purpose of supplying clean air to the motors, fourteen cubicles of electronic air cleaning apparatus have been supplied. These air cleaners are serviced by a semi-automatic washer to provide means for flushing off the collected dirt and re-applying adhesive with a minimum of manual labor. Power for these units is supplied by 14 self-contained high voltage rectifiers. These units operate on 115-volt, single-phase, 60-cycle alternating current and deliver 13,000 volts d-c for the ionizer and 6000 volts d-c for the dust collector.

The clean air is drawn down through the motors into the motor room basement from whence it is returned to the cleaning units through a large air duct. Auxiliary electrical equipment also contained in the motor room includes:

A 750-kva cubicle unit substation, 440 volt, 3 phase, 60 cycle, for supplying a-c power for blowers, pumps, air compressor and lighting.

A 500-kw, motor-generator set, furnishing 230 volt, d-c power for cranes, table motors and other auxiliary motors.

A 300-kw, motor-generator set, furnishing 140/460-volt d-c power for reel motors.

A 30-hp, variable speed unit for supplying power to the conveyors.

A special three-generator motor-generator set of 30 kw each for supplying d-c power to the flying crop shear motors.

Seven large station type load meters are installed in the mill proper as an indication to the operator of the loads on each motor. In addition, each of the main mill motors and each generator are equipped with graphic meters to chart the loads on each piece of equipment and the speed of each of the main mill motors. These graphic meters have been useful in obtaining test data for engineering purposes.

CHARGING THE BILLETS

The first step in charging the billets into the furnace is accomplished on a set of mechanical skids which is known as a "bundle buster." The skid operation in our old mill was manually accomplished by skid men using crow foot wrenches; however, it was apparent that the problem of feeding billets weighing over 600 pounds at the required rate demanded mechanical assistance to eliminate unnecessary manpower. This "bundle buster" operates in an extension of the billet yard from a common crane runway serving the billet mill cooling bed and the billet storage yard, as well as the mechanical skids. Two 15-ton, electric overhead traveling cranes handle all of the operations on this runway. The bundles of billets are placed on a receiving table and slowly moved to a series of three sets of separating wheels with each set of wheels moving slightly faster than the previous set. By this means the billets are separated and lined up to be deposited on a horizontal storage bed, across which they are moved by a walking beam and placed, one at a time, on a furnace run in table. Kick off arms are provided at this point to reject any unsuitable billets into either of two cradles. Billets are normally charged three at a time by means of a self-propelled furnace charging car.

THE FURNACE

The furnace is side charging and served by the usual rocker arm type of cross pusher. The inside width of the furnace is 33 ft and the distance from the center of the charging door to the center of the discharge door is 49 ft. The construction of the furnace is of the single zone type fired from the discharge end by combination burners designed to use either natural gas or bunker C fuel oil. Fully automatic controls regulate the temperature of the furnace, furnace pressure and fuel-air ratio. Continuous charts are provided showing these factors together with charts showing the temperature of the gases leaving the furnace, temperature of the preheated air and temperature of the stack gases. A high percentage of the sensible heat in the waste gases is utilized for preheating combustion air supplied by two pass metallic recuperators. Furnace temperature is measured by radiation pyrometers placed in the roof near the middle of the heating zone. With this furnace temperature normally reading 2250 F, the gases leaving the furnace will be approximately 1200 F, combustion air is normally about 700 F, and the gases entering the stack measure approximately 500 F. Fuel consumption is normally 1,200,000 to 1,500,000 Btu per ton. The billets leaving the furnace are indicated as being approximately 2000 F by use of an optical pyrometer.

STARTING THE BILLETS INTO THE MILL

A conventional pusher bar is used to eject billets from the furnace and into the first stand of the roughing mill. Each of the three lines is worked consecutively through the application of an ingenious 3-strand switch table. The middle section of this table is fixed at the billet pass elevation and is shaped in the form of a "V" with the funnel end towards the furnace; the outside sections, having integral side guards, are mounted so that when they are elevated the side sections form a wide mouthed path to direct the billet into the proper pass, and at the same time lift the preceding billets out of the way. The entire table is traversed sidewise across the pass line by the selective combined action of the two air cylinders and links. Each of the three strands is served by delivery pinch-rolls and rugged air operated billet shears as auxiliary tools.

ROUGHING TRAIN

The roughing train consists of eight stands of rolls equipped with straight bore tapered roller bearings. To date, no bearings have been lost on the roughing mill. Individual bearings have accumulated service life of over 6,600 hours. Stands 1 and 2 are 6-in. mills driven by a single 400-hp, d-c motor. Rolls used in stands 1 and 2 are 17 x 28-in. Stands No. 3 to No. 8 are 15-in. mills driven by a single 1,500-hp, d-c motor. Rolls used in these stands are approximately 16-in. in diameter by 28-in. bodies. Oval passes are used in stands No. 1 and No. 3, diamond passes in No. 5 and No. 7 with the even numbered stands being squares. No excessively high reductions are used and the shear section is approximately $\frac{3}{4}$ in. square. The original billet which was 30 ft long is then approximately 300 ft long and the speed of the bar has increased from approximately 30 fpm to over 350 fpm. These mills are extremely sturdy with the 16-in. mills having a nominal post area of 120 sq in. each and the 15-in. mills having a nominal post area of 95 sq in. each. This factor of sturdiness was one for which we were grateful many times during the early operations when considerable cold rolling was attempted. All twist delivery guides in the roughing mill are equipped with roller twisters.

Three identical pass lines are maintained in fixed position for all sizes of rods and multiple grooves are provided in each roll. The roll stands are easily moved horizontally to bring new grooves into the pass line when the grooves become worn.

THE FLYING CROP SHEARS

As far as is known to the author, this is the only steel rod mill in operation which has a separate flying crop shear for each strand and operates completely automatically to crop the front end from each bar. No shearman is employed by the mill. The shearing impulse is received by electric eyes located before No. 7 stand and the control circuits incorporate adjustable time delay relays which activate the shear motors to crop the front end of each bar at the precise time when the leading end first enters the shear. Crop lengths are maintained very closely and more uniformly than would be possible by manual control. A manual control station is located on the mill floor and control buttons are also installed in the main mill pulpit. By using the manual control the shears will cut continuously to remove cold front ends or to scrap a billet which should be restrained from continuing through the mill.

THE INTERMEDIATE TRAIN

Eight 12-in. mills comprise the intermediate train, stands 9 through 16. These stands are arranged in pairs known as duo mills. Each pair is driven by a separate 800-hp, d-c motor. The rolls are approximately 13 in. in diameter by 24 in. long. Tapered bore roller bearings are used on all roll necks in the intermediate train. Although some bearing failures and partial failures have occurred on the intermediate stands, life has generally been satisfactory, with some bearings now showing a service life of over 5,500 hours and which are still in service. Spaces are provided before and after each pair of stands so that free running loops can form, thus relieving any rolling strains which may have developed. Since the mill layout is not in a straight line, it is necessary to repeat the bars to reverse the direction of travel. There are three 180-degree repeaters in this mill which provide free running loops that are allowed to grow slightly in the length on the repeater tables. Since the first two sets of duo mills are in a straight line, it is necessary to accomplish this looping action by means of down loopers which are straight troughs used to guide the front end of each bar between these duo stands. When the passage of the front end has been accomplished, the trough is automatically turned over, which allows the loop to spill out. Thus the mill has been provided with five such loops which greatly minimize the opportunity for and the effects of stretch. This feature facilitates the rolling of rods which are virtually the same size from the front end to the back end of the coil and extremely close tolerances can be maintained.

Oval, square and round passes are used in the intermediate train to reduce the bar to a round slightly larger than $1\frac{1}{32}$ in. in diameter. The speed of the bar leaving the intermediate train has been increased to approximately 2,000 fpm and the bar is then approximately 1,900 ft long when 0.218 in. rounds are being finished in stand No. 22. All eight stands in the intermediate train are used for all rod sizes up to $\frac{25}{64}$-in. On larger sizes either four or six of the intermediate stands are used and the rod is finished from stand 15. All twist guides in the intermediate train are also equipped with roller twisters.

THE FINISHING TRAIN

When rolling smaller rounds, the bar travels around a 180-degree repeater from No. 16 stand and into the six stand finishing train. A 2,000-hp, d-c motor drives this train through a precision gear set so that 0.218 in. rounds are produced at a speed normally set at 5,000 fpm although the mill can and has operated at 5,750 fpm, or over a mile a minute. Since there are three bars in the mill simultaneously, the mill can actually produce over three miles of 0.218-in. rod per minute.

Tapered bore roller bearings are used in the finishing train. Again a few failures and partial failures have occurred on finished mill bearings; however, some bearings have accumulated service life of over 4,000 hours that are still in service. All new rolls for the finishing train are first used in stand No. 21 or No. 22 and are 11¼ in. x 20 in. After using ⅜ in. off the diameter of the rolls, they are moved back to stands No. 19 and No. 20 where another ⅜ in. is used from the diameter. They are then moved back to stands No. 17 and No. 18 for a final ⅜ in. reduction in diameter. Pinion sizes are established at 11 1/16 in. pitch diameter for stands No. 21 and No. 22; 10 1 1/16 in. for stands No. 19 and No. 20; and 10 5/16 in. for stands No. 17 and 18. In other words each pinion has a pitch diameter half way between the new and used size of each roll with which it operates. Since no greater variation in diameter than ⅜ in. is experienced in the rolls, the finishing mill spindles are never operating at more than 3/16 in. from a true horizontal position. Coupling boxes on both finishing and intermediate trains have inside ring gear teeth which mesh with spur type gears on the drive spindles. All such gear teeth are precision cut in a dihedral pattern to provide extremely smooth and quiet operation. The center shaft of the drive spindles is formed from tubing to reduce weight and each coupling box affords space for sufficient sidewise movement so that the box may be removed from the roll wobbler.

Oval and round passes are used in the finishing train to produce rounds from 0.218 in. diam to 0.375 in. diam. Bronze guides are used on both entry and delivery sides of the finishing mills. Relatively extensive trials have supported the economy of using titanium carbide inserts on pointer guides to enter ovals into round passes. As used in our mill, these inserts are initially placed in stand No. 22 and moved back to stand No. 20. Such guides are usually stoned after each 8 hours' service and ground at least once during their life in each stand. These inserts have exhibited a useful life of over 500 hours in stand No. 22 and a total life of over 600 hours. The appearance of moderate fire cracking does not seem to impair their useful life and if properly mounted, used and maintained, excellent results are obtained.

COILING THE RODS

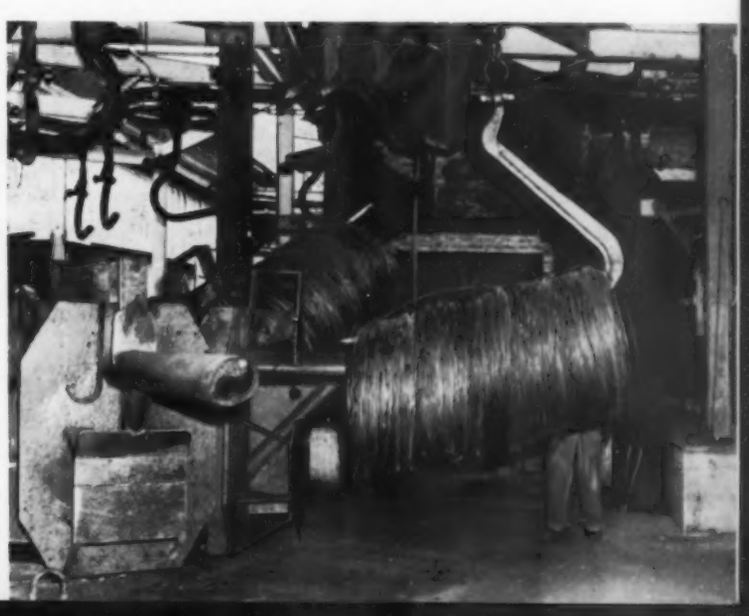
Each of the three strands of rods coiled by the laying reels is served by two coilers with the hot rods from each strand alternately directed from one coiler to the other by means of an automatic switch. The hot rods travel from the switch to the coilers through a high pressure water descaling system which facilitates the obtaining of the improved surface quality. After the coiling has been completed in one of the six laying reels, the coil is automatically discharged from the coiler on the conveyor system composed of five conveyors.

Immediately following the switch pipes is an electric eye. When the front end of the rod passes this eye the impulse activates a quick opening valve to supply cooling water for the descaling system. As the last end of the rod passes this eye, the switch pipe is automatically moved to serve the companion coiler and the water is automatically turned off. At the same time the reel tub which forms the outside periphery of the coiling space is automatically lowered. As the rim of the tub reaches the elevation of the receiving table and reel platen, a limit switch activates the coil pusher to deliver the coil on a high speed slat conveyor. As the coil pusher starts to retract, the conveyor automatically delivers this coil quickly to the transfer point, automatically slows down and stops under the influence of two other electric eyes, one of which activates a cross pusher to deliver the coil in front of a set of pusher dogs on the drag conveyor. Meanwhile, the reel service pusher has fully retracted and the reel tub has automatically raised in position to accept the next coil. Electrical interlocks are provided which insure that the coil enters the drag conveyor properly spaced between pusher dogs. Other similar interlocks prevent the slat conveyor from delivering a coil until the cross pusher is in a position to receive another coil. Also, only one coil can be on the slat conveyor at a time in normal operation, and reel tubs are restrained from raising until the reel service pusher is completely retracted. Manual controls for these operations are provided but seldom used, since the automatic operation is over 99 per cent effective.

A corresponding series of actions occurs at the pour-

Figure 4 — Six automatically-operated laying reels coil the 600-lb bundles. A system of five conveyors also automatically handles the products of the mill.

Figure 5 — The rotating six-arm unloader automatically collects the coils from the hook conveyor, groups them in lifts of five bundles to be further processed or placed in storage by cranes or ram trucks.



ing reels when large rods are being rolled with the exception that holding aprons are provided between the pin reels and the drag conveyor in place of the high speed slat conveyor. This permits the coils to be placed on the drag conveyor in proper relation to the pusher dogs. A separate series of descaling troughs is used for large rods and a system using four of the mill conveyors is employed. Large rods finished in stand No. 16 have been finished at speeds up to 2,700 fpm.

THE CONVEYOR SYSTEM

In addition to the high speed coil conveyor, which is 45 ft long, a drag conveyor, 240 ft long, is used, which is composed of three sections. The first section is a double chain type, 135 ft long. The second section is a single chain conveyor, 75 ft long, and the final section is a double chain type, which is 30 ft long. The drag conveyor delivers the coils to a hook conveyor approximately 1,400 ft long, of which about 900 ft is loaded and 500 ft is return run.

The transfer of each coil from one conveyor to another is automatically accomplished and sufficient time is afforded for the coil to cool and undergo inspection and testing before it reaches the unloader at the rod storage building. After cooling on the conveyors, the coils are automatically unloaded onto a mechanical rotating device having six long receiving arms. As a conveyor hook carrying a coil of rods reaches the unloader, the hook is cammed upward and back, thus discharging the coil on one of these receiving arms which is elevated to approximately 25 degrees. This allows the coil to slide forward on the arm. When five coils have been deposited on an arm, the mechanism automatically rotates one sixth of a revolution, another arm is raised to receive its load of five coils, and the previously loaded arm is stripped by one of two 5-ton electric overhead traveling cranes or by a ram type tractor.

With hot steel traveling through the mill at high speeds, every conceivable safeguard is employed to confine the hot bars so that hazards are minimized. The entire finishing train and reel switch is caged in, other guards are used to protect employees from hot bars wherever possible, and each of the three strands is provided with five strategically located shears which can cut off any misdirected bar. The shear immediately ahead of the finishing train is equipped with a timing device which will automatically cut off any bar that does not accomplish its normal course through the finishing mills. This feature greatly reduces the amount of scrap accumulating from a cobble inside the finishing cage. Similar air operated clip shears are provided for each strand at the delivery end of each repeater. Any of these clip shears can be manually operated from the floor near the shear, from either reel pulpit, or from the main mill pulpit; however, as a safety measure, the shear once tripped stays closed and can be reset only from the floor station near the shear.

The production of high quality rods has been the principal emphasis in the development of this mill. Due to the economic situation when starting operations, the mill was not pushed for tonnage, and considerable deliberate experimental work on guides, pass design, roll diameters, and rolling layouts were undertaken. An unusually strong effort has been expended to eliminate stretch from the mill with the result that perfectly clean sections are rolled throughout the entire length of the bar on all stands up to and including number 16. A back end trimming of only one half ring is cut from 0.218-in. rods. The capacity of the mill is normally 50 net tons per hour. The mill has attained tonnages of over 53 net tons per operating hour on rods coiled in the laying reel. Since only three pouring reels were originally installed, large rods have been rolled double strand at a slightly reduced rate; however, at the

Figure 6 — A view of the pressurized motor room shows some of the main mill motors, motor-generator sets and control equipment. This motor room is continuously supplied with filtered air.

Figure 7 — In the bearing maintenance room, skilled mechanics care for the anti-friction roll neck bearings and roller twister guides used throughout the mill to contribute towards precision rolling.

present time three additional pouring reels are on order, which will provide the capacity for rolling large rods at a rate in excess of 50 net tons per hour.

At the time this mill was placed in operation only a few people connected with Continental Steel Corp. had ever seen a continuous rod mill; however, all jobs, including supervision, were filled with employees from our old hand mill, and we all learned about the operation together. Through exceptionally loyal and industrious work on the part of our supervision and crews, and with assistance furnished by the mill builder and competent consultants, we feel that we have progressed a long way. We still have much progress to make but we are pleased with the results we have obtained and anticipate that our future experience will be highly gratifying.

DISCUSSION

PRESENTED BY

FRED T. VAN CAMP, Superintendent Rolling Mill, Wickwire Spencer Steel Div., The Colorado Fuel and Iron Corp., Buffalo, N. Y.

DON C. HORSMAN, Assistant General Superintendent, Continental Steel Corp., Kokomo, Ind.

WILLIAM A. MILLER, Superintendent Rolling Mills, John A. Roebling's Sons Corp., Roebling, N. J.

EARLE L. CHAMBERLAIN, Division Superintendent Hot Mills, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio.

R. J. LANE, Assistant to Project Engineer, Lewis Foundry and Machine Div., Blaw-Knox Co., Groveton, Pa.

SHERIDAN A. SMITH, Superintendent of Rolling, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

L. M. MEYER, Field Engineer, The Timken Roller Bearing Co., Pittsburgh, Pa.

Fred T. Van Camp: First, what out of round variations do you find from front to back end of coil, and to what tolerance do you hold your rod sizes?

Second, do you find any difference in tensiles, due to the large bundles, and the variations of cooling from inside strands to outside strands?

Third, I noticed that you have tubs on the outside periphery of the coiler. In your opinion, would pins be of any advantage in getting rid of accumulated heat in the reel?

Finally, have the safety features which you have spoken of, worked out to your entire satisfaction, or is there anything you might change or add if you were starting from scratch now, with the experience of the past two years to aid you.

Don C. Horsman: The first question is on tolerances. I am not sure when you ask what tolerances we are able to hold, whether you are talking about the potential of the equipment, or performance in operation. I would like to answer that question this way. We have held tolerances to plus or minus 0.005 in. on a heavy percentage of the rods produced over a substantial length of time. I do not mean that we never get rods outside of that tolerance, but it is my candid opinion, and I have personally worked on the mill myself, that the mill can, if operated properly, roll within the tolerance of plus or minus 0.005 in. I have seen this done over a substantial period of time.

I might say that this is not the tolerance we use for rejection purposes. We take the full 0.015 in. over and under before we reject rods.

You asked about differences in tensiles due to variations in cooling of the inside and the outside strands. We are not aware of that feature causing us any difficulty. Of course, we do recognize that the inside strands of the coil cool more slowly. However, one factor in our situation is that practically all of our product is low carbon rod, and the difference in cooling rate on our product would not be marked enough to cause us any difficulty. I could well imagine that the difference in cooling rate might cause more difficulty on high carbon or alloy rolling.

With regard to the use of pins instead of tubs on the laying reels, that is a subject which has been discussed pretty thoroughly. I think that the pins would allow better cooling in the reels; however, we have not been aware of any difficulty from not having had that extra cooling. The lack of such cooling has never, as far as we have been able to detect, caused us any difficulty at all.

With respect to safety features, I am of the opinion that whatever practical safety features anyone in your organization might think of, or suggest, should be installed. As of last Saturday at 3:00 pm when we shut down for the weekend, we have not had a disabling accident in our mill, for which we are very thankful. However, things happen very fast when you are shooting steel through a mill at around 5000 fpm. I do not think you can get too many safeguards.

We have screened in the finishing cage. We have provided at least side shields and some canopy shields at the repeaters and shields at all of the crossovers. We think that our clip shear design has been very advantageous. All of our operators are cautioned that if at any time they are going to work on any line, then they must close that shear. This serves several purposes. First of all, if a bar does get into that line, it can not get into the mill. The shear once closed stays closed until the man on the job opens it again.

In the second place, when a shear is closed, it activates a system of electrical eyes, so that any time a billet is started into that line where the shear is closed, there is a loud bell which sounds and notifies the crew that they either have to get the line open quickly or start chopping the bar up because it is not going to go through.

At the moment I can not think of anything else in the way of safety precautions. Perhaps our boys were somewhat more conscious of the hazards of high-speed operations than some of your fellows would be who have operated continuous mills for a long time, because on our old hand mill about the fastest that we ever saw a bar travel was around 1,750 fpm, and it honestly looks a good bit faster when you are rolling at 5000 fpm.

All of us, I would say, had a pretty healthy respect

for that speed, and we did not have any carelessness. In fact, we doubtless had just the opposite, which is an over-concern, but that is something that we were glad to see from the standpoint that we certainly did not want to get anyone hurt.

William A. Miller: I would like to ask if you use the bronze guides both as receiving and delivery guides; also do you use roller twister guides up to and including the intermediate mill. If so, what type of bearing do you use with them?

Don C. Horsman: We do have bronze guides on both the delivery and receiving side in the finishing mill. Roller twisters are used, as stated, up to and including stand 15, which is the final oval in the intermediate train.

Yes, we have had some difficulty with roller twisters. The bearings are standard tapered roller bearings. We started out using the roller itself as the outside race of the roller bearings. In other words, we used the bearing without the cups. What we ran into was that it was very difficult for us to get a material which was hard enough to withstand the action of the rollers without wearing excessively and still withstand the shock and abuse of the mill without spalling or chipping.

We have changed the design of the roller guides by making the guide rolls out of about a 0.40 or 0.45 per cent carbon steel and having a full roller bearing, including the outer race, inserted in the guide roller.

Our master mechanic first tried this idea by having a set of guide rolls made out of an old screw from a blooming mill screw-down, and it worked fine. So we have been changing over from the hard alloy rolls and are using a cartridge mounted guide roll on the outer race of the tapered roller bearings.

Earle L. Chamberlain: You say you normally roll 0.218 in. rods at 5000 fpm. What problems do you encounter at this speed in reference to laying reel pipe sizes and finishing guides and twisters and receivers, and is there any noticeable build up in coil temperatures at these finishing speeds? What difficulties do you encounter at 5,750 fpm with the same thoughts in mind?

What are your thoughts on ovals in number 1 and 3 stands and diamonds in 5 and 7 stands with reference to quality and reductions, and how many hours approximately, are you getting on your finishing mill passes and your roughing mill passes?

Don C. Horsman: In finishing rod at 5000 fpm we found that the size of the pipes into the laying reels was extremely important. I recall, on about the first day we had the mill equipment assembled and were trying to operate, the electrical people that supplied the mill motors were anxious to get test data on their electrical equipment. So they came in with a staff of specialists and truck load of equipment. They said, "Now we want to take this test data with three strands in the mill at 5000 fpm." In other words, they wanted to get the data at rated load and rated speeds.

We started in at 7:00 o'clock in the morning, and it was 10:00 o'clock that night before we ever got three rods simultaneously running at 5000 fpm. We did that once and knocked the mill off and went to bed. We later found out that the biggest factor in our trouble was that the large lead pipes were causing difficulty at the reels. It seemed that the bar started into the reels and then would buckle in the pipes and break off with only 1, 2 or 3 wraps around the pins. With infinitesimally fine adjustment of the reel speeds we could get the rod to coil so we thought we were having trouble in holding reel speeds. However, it later proved that at least about 95 per cent of the difficulty was caused by the size of the reel pipes. When we got up over about 4500 fpm, the shock of the bar going in the reels threw a wave back in the rod, and hot bar did not have sufficient column strength to keep it from buckling in the larger pipes.

In the original installation we had 1¼ in. pipes for the rod to travel through, and that gave it quite a chance to wave and buckle.

At the present time we are using ¾ in. extra heavy pipe for the laying reel pipes, and we think that this has been important in the success of the operation at higher speeds. We are even using ½ in. switch pipes, although I do not know that that is necessary. We tried that size and it worked all right, so we did not change it.

As to difficulty with finishing guides, twisters and receivers, we experienced a lot of difficulty early in our trial operations. The two problems that we ran into at high speed were those of friction creating heat (and getting the heating dissipated quickly) and also the abrasion of the bar on the guides.

We did considerable experimenting with twist angles. We were surprised to find that we had to increase the twist angle in the neighborhood of 80 per cent more than the theoretical twist angle. Then we had things going pretty fair, and we decided we were not getting enough guide life. So we started looking for a harder material, and when one such material looked pretty good, we put guides of this material all through the finishing mill. As soon as we got them all through the mill, we had more cobbles, guide smearing and pick-up on the guides than we could cope with, and we had to go back to our softer guides.

I think also that the bearing length is important. It is undoubtedly a matter of controversy, but we do not like to have too long a straight bearing length on the receiving guide. We hold it down to two inches or less from the point, not trying to support the bar too far back, because we feel the longer bearing length you have on the guide, the more friction and more heat you create, which in turn introduces other problems.

Now, as to build up of temperatures in the finished bundle, I do not know exactly what you are referring to.

The heat flows back to the surface of the rod somewhat after it is discharged from the coiler. I think that is due to the fact that since the rod is traveling so fast, you actually just chill the rod surface, and it remains hot inside. This is particularly evident in the center of the coil. The heat of the inside of each strand flows back to the outside and it does appear to exhibit a pick-up in the apparent temperature of the finishing coil. Of course, there is no possibility of an energy pick-up. It must be a redistribution of heat.

Earle L. Chamberlain: What I had in mind was the pick-up in temperature on the last 5 or 6 strands, as

it is being coiled are hotter than the rest of the coil. Have you noticed any particular difference in that?

Don C. Horsman: No, we do not notice such a difference.

Earle L. Chamberlain: In other words, you do not think you get any temperature build-up in the finishing mill running at maybe 5700 fpm?

Don C. Horsman: I thought you said in the finished coil. We do get a temperature pick-up in the finishing mills from stand 16 to 22, but it is uniform throughout the length of the bar. As read with an optical pyrometer, we get something like 60 degree pick-up going through the finishing mill. As far as 5750 fpm rolling, I would say the temperature raise would be just about the same.

This next question was inevitable about the use of ovals at stands 1 and 3 with diamonds in stands 5 and 7, because I think almost everybody knew we started out with diamonds in the roughing mill and we like diamonds, and we still would use them except for one thing. That is we felt we needed more reduction in the roughing mill than we could get and maintain a quality bar using the diamonds. We put ovals in one and three, which are stands where you can adjust motor speeds to match the change in reduction. Since stands three to eight are all geared together on one motor, we did not attempt to change five and seven. In fact, we like the diamonds in these stands.

On the roll passes we are running a little over eight hours on finishing mill passes (a set number of bars which produces around 340 tons on the finishing mill pass). We run something like 1300 bars right at the present time.

We are getting two turns on numbers 15 and 16 passes; three turns on 13 and 14 passes, and we get either four or five turns per pass on 11 and 12 passes. We roll 6 to 8 turns on 9 and 10 passes. In the roughing mill we are running the first four set one week and the last four set we are changing in the middle of the week and at the end of each week.

I might say that we have not determined whether that is the maximum life possible. It might well be that we will find that we can run more than that.

R. J. Lane: I would like to ask Mr. Horsman a question with regard to the sequence of operations while pushing three bars out of the furnace and how you have solved the problem of bars crossing each other with the number 4 bar being pushed while numbers 2 and 3 bars are only partially out of the furnace. This would become even more of a problem in a four-strand mill.

Don C. Horsman: I can imagine it would become a considerable problem in a four-strand mill. The operators out in the mill have developed a system pretty much on their own, which was one of those night shift experiments. It seemed to work, and so again when something is working, we do not interfere with it. They get the three billets down on the flat hearth and they go in with the pusher bar and pick off the third billet from the burner and feed that into number 3 pass, feed number 2 into the middle pass and the near billet into number 1 pass. Then they push down three more and go through the same cycle again.

It looks like a lot of trouble to pick that third billet out of the middle, but they are satisfied they are getting better results with such a system and apparently they do. At least that number 3 bar is out of the way before you have to push down with the cross pusher. The number 1 bar is pretty well out of the way, and instead of the running billets crossing, they will be shoved on further toward the bridgewall of the furnace.

I know that most of you are not using this practice, and I think that it depends greatly on what system your crew can become accustomed to best.

Sheridan A. Smith: I think you know the only difference in our two mills is that we are set up on four strands but only operate three at a time, taking them in rotation and have had no trouble whatever.

Don C. Horsman: That is the way most mills do and they do not have any trouble.

Sheridan A. Smith: I would like to ask a question. What is your acid consumption per ton as this will give me a comparison of what we are doing in our plant?

I have been experimenting with water for the last year and a half. It has been one of my biggest headaches trying to get an average temperature below 1500 F but our metallurgical department have been after me to try and get lower, as it will lower the acid consumption, but in doing this I have trouble with cobbles in the laying reels.

Don C. Horsman: In order to compare results, you have to be comparing the same size bundle. On our old mill we were running a 225 or 230 lb coil, and the rod finished cool because this was a looping mill and you could not finish hot. With the long loops laying on the looping floor, we were lucky to have any color left in the rod when it finished.

The scale condition on rods from our looping mill was not too bad. It was a small bundle and cleaned nicely. We had cleaned the small coil in 14 or 15 minutes.

Our acid consumption has never been extremely low. I think at that with small coils it was around 50 pounds per ton. On the 600-lb coils we had trouble at first getting temperatures down. Right now our acid consumption is up around 65 lb per ton, and the cleaning time is 25 to 30 minutes.

We are finishing in the laying reels now between 1,350 and 1,450 F, as we read it with an optical pyrometer. I do not believe you can compare results obtained with one optical pyrometer as against another always, but that is what we are reading.

In regard to your question, I can say that we definitely can get the rod too cool. We have had the rods so cold we could not coil them successfully. They look black sometimes coming out of the reel pipe.

L. M. Meyer: You spoke of performance of antifriction bearings on the roughing, intermediate and finishing stands in terms of operating hours. Do you have the corresponding figures of performance in terms of tons and their relation to gross mill tons?

Don C. Horsman: I do not have them with me. However, if you multiply the operating hour figures by 40 net tons, this will give a close approximation of the bearing life in mill tons rolled.

By T. F. BARNHART, Senior Process Engineer, Chemical Plants Div., Blaw-Knox Co., Pittsburgh, Pa.

Evaluation of a Waste Pickle Liquor Treatment

. . . . a new process for treating pickle liquor developed in Europe has recently been introduced in this country . . . . advantages of the process are recovery of the pickle liquor as reusable sulphuric acid, only by-product is iron oxide which can be used by steel plant, and recovery of inhibitors . . . . only raw material normally needed for operation is some makeup hydrochloric acid . . . .

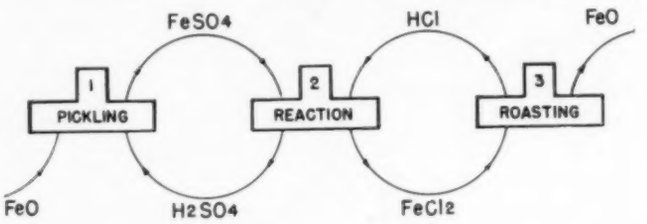
▲ THE removal of iron oxide scale is an essential step in the manufacture of many steel products. This is accomplished by immersing the steel in a tank containing a heated solution of dilute sulphuric acid. Iron oxide reacts with the acid to form ferrous sulphate, and the scale-free steel passes on to subsequent operations. This process is called "pickling" and may be subdivided into two types, namely, batch pickling and continuous pickling.

In the case of batch pickling, the steel is immersed in a tank of sulphuric acid and allowed to remain in a more or less stagnant manner for a predetermined period of time after which it is rinsed in a cold water rinse tank. In the case of continuous pickling, the steel continuously moves through the pickling and rinse tanks. Waste pickle liquor from batch pickling operations generally contains about 2 per cent free sulphuric acid and 18 per cent ferrous sulphate. Waste pickle liquor from continuous pickling operations generally contains about 5 per cent free sulphuric acid and 14 per cent ferrous sulphate. A stronger pickle liquor is needed in continuous pickling because of the shorter contact time in the pickling tank.

It is difficult to obtain an accurate estimate of the volume of waste pickle liquor produced in this country. However, it has been estimated that more than 600,000,000 gal per year are produced. Because of the highly acidic nature of this waste, it has been a particular concern of regulatory bodies. A number of states have passed stream pollution abatement laws which require the treatment of waste pickle liquor previous to its discharge to waterways.

In the past, a great deal of research has been conducted on pickle liquor disposal. For those who are interested in the history of pickle liquor treatment, a recent publication issued by the Ohio River Valley Water Sanitation Commission, entitled, "Disposal of Spent Sulphate Pickling Solutions" is recommended. The purpose of this paper is to discuss a new and unique waste pickle liquor recovery process whose basic reaction was discovered by Mr. Othmar Ruthner of Vienna, Austria. Mr. Ruthner spent three years doing concentrated research on this process. Based on this work, patents have been issued in a number of European countries and a patent application has been filed in the United States.

Our company has signed a license agreement with Mr. Ruthner, which gives us the exclusive rights to offer the process in North and South America. For the past year and a half, the process has undergone extensive development by us, including laboratory work, equipment testing, and process engineering, to adapt it to American practices and standard American equipment. Based on these data, a tentative design for an operating plant has been completed.



$$FeO + H_2SO_4 \longrightarrow FeSO_4 + H_2O$$
$$FeSO_4 + 2HCl \longrightarrow FeCl_2 + H_2SO_4$$
$$FeCl_2 + H_2O \longrightarrow 2HCl + FeO$$

Figure 1 — Basic chemistry of process is given in this schematic diagram.

Before proceeding with a discussion of the process steps, it would be well first to take a look at the basic chemistry involved. This can best be demonstrated by the diagram in Figure 1.

The curved line on the left represents iron oxide scale present on the steel to be pickled. As it enters the

pickler, it is contacted with sulphuric acid and the reaction represented in Equation 1 takes place:

$$FeO + H_2SO_4 = FeSO_4 + H_2O$$

Scale-free steel passes out of the pickler to subsequent processing. The ferrous sulphate solution which is formed in the pickler is then concentrated and transferred to the reactors where it is contacted with hydrogen chloride gas reacting according to Equation 2:

$$FeSO_4 + 2HCl = FeCl_2 + H_2SO_4$$

It should be noted that the sulphate equivalent of the ferrous sulphate is recovered as reusable sulphuric acid by simple chemical reaction, thus eliminating the need for an expensive contact or chamber sulphuric acid plant. It is this feature that distinguishes the process from other previously proposed recovery processes. Recovered sulphuric acid is then returned to the pickler to complete the sulphuric acid cycle. Ferrous chloride from the reactors is transferred to the furnace and roasted according to Equation 3:

$$FeCl_2 + H_2O \_\_\_ FeO + 2HCl$$

In this manner, hydrogen chloride is recovered and recycled back to the reactor to complete the hydrogen chloride cycle. Iron oxide passes out the bottom of the furnace as practically pure iron oxide which, when sintered, may be charged back to the blast furnace, thus eliminating disposal or sale of any products from the process. The diagram plainly shows that the process is entirely cyclic, with the exception of iron oxide which is recovered in usable form. The only hydrogen chloride supplied is to make up for incidental losses from the system. The only sulphuric acid required is to make up for incidental losses from the system and the much larger rinse water loss that never reaches the recovery plant.

Figure 2 shows a flow diagram of a commercial plant using the process. The waste pickle liquor is first pumped to an evaporating system and concentrated. The evaporator is of the external-reboiler, forced-circulation type.

Fresh waste pickle liquor is mixed with recirculating slurry and passed through a graphite heat exchanger, where it is indirectly heated with steam. The superheated mixture discharges to a flash chamber, operated at about 50 mm Hg absolute pressure, and a portion of the water is evaporated. A side stream of concentrated slurry is continuously withdrawn to the reactors. The evaporator is operated under vacuum and at a temperature which permits the use of rubber lining as a corrosion preventive. The purpose of the evaporation step is two-fold; first, to produce concentrated sulphuric acid for reuse in the pickling system; and second, to reduce the solubility of iron salts in the pickle liquor, since the solubility decreases with increasing acid concentration. When the acid concentration of waste pickle liquor is low, with resultant high ratio of solids to acid, then evaporation to the desired acid content results in a slurry too thick to pump. In that case, finished acid is recirculated to the evaporator.

Concentrated sulphuric acid-ferrous sulphate slurry from the evaporator is cooled and pumped into the first of four reactors connected in series. Hydrogen chloride gas enters each of the last three reactors through a sparger at the bottom. Ferrous sulphate and hydrogen chloride gases are converted to ferrous chloride and sulphuric acid. Since the reaction is exothermic, cooling is required.

Reactors are cooled by a number of internal bayonet type cooling fingers through which chilled water is circulated. The contents of the reactors are also agitated to aid in keeping the slurry in suspension and to distribute hydrogen chloride gas through the liquid. Vent gases from the last three reactors, containing a small amount of hydrogen chloride, are collected and sparged into the bottom of the first reactor, into which concentrated pickle liquor is fed. No direct feed of hydrogen chloride gas enters this tank. Its sole purpose is to deplete the vent gases of substantially all of the hydrogen chloride before they are vented. Slurry flows from one reactor to another by gravity, requiring approximately eight hours for complete passage. Slurry from the final reactor overflows by gravity to an agitated slurry surge tank from which it is pumped to the centrifuge. To prevent reversion of the reaction products, a small amount of hydrogen chloride gas is continuously sparged into the slurry in the tank. Vent

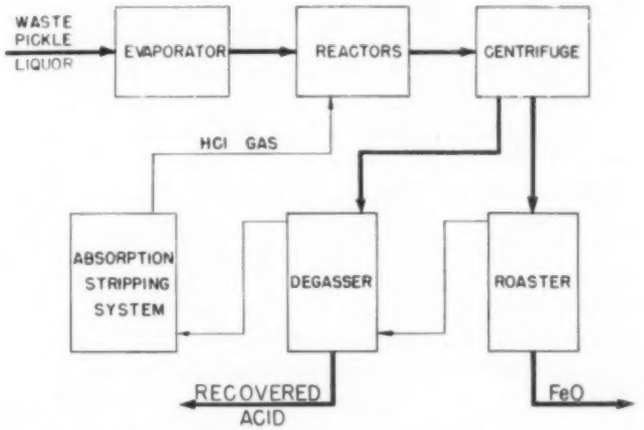


Figure 2 — Schematic shows flow diagram of a commercial waste pickle liquor recovery plan.

gases from this tank containing a small amount of hydrogen chloride is also sparged into the bottom of the first reactor. Sulphuric acid-ferrous chloride slurry is pumped from this tank to the centrifuge, where sulphuric acid and ferrous chloride are separated.

Final cake is washed with concentrated hydrochloric acid to remove adhering sulphuric acid mother liquor, filtrate and acid wash then flowing by gravity to the surge tank for recovered sulphuric acid. Sulphuric acid at this point is still saturated with hydrogen chloride which must be removed before reuse.

Ferrous chloride is fed to a multiple hearth roaster, direct-fired with oil or gas. Under the influence of heat, ferrous chloride is converted quantitatively to hydrogen chloride and iron oxide. Iron oxide product, practically free of sulphur, phosphorous, and chlorine, is removed from the furnace by a water-cooled conveyor which cools the calcine and discharges it to portable shipping containers.

Hydrogen chloride produced in the roasting reaction, along with all the inert products of combustion, flows to the bottom of the degassing tower.

The degassing tower is a packed column constructed

of materials especially chosen to withstand the temperature and corrosive chemicals. Filtrate from the centrifuge, along with acid wash, is pumped from the surge tank for recovered sulphuric acid to the top of the degassing tower where it is contacted counter-currently by hot furnace gases. Sulphuric acid is completely stripped of hydrogen chloride in this operation, and chloride-free acid is recycled from the bottom of the tower to the pickling line for reuse.

Gases leaving the degassing tower contain all of the hydrogen chloride previously used in the reactors. These gases flow to an absorber where hydrogen chloride is absorbed in 21 per cent hydrochloric acid solution. Inert gases, substantially free of hydrogen chloride, are vented through a tails scrubber to the atmosphere. Concentrated hydrochloric acid solution, formed by absorption of hydrogen chloride, is pumped from the bottom of the absorber to a steam heated stripper. Here pure hydrogen chloride gas is recovered as overhead and 21 per cent hydrochloric acid solution as bottoms. Hydrogen chloride gas is recycled back to the reactors, and 21 per cent hydrochloric acid is cooled and recycled back to the absorber. A portion of the concentrated hydrochloric acid solution formed in the absorber is used as acid wash in the centrifuge.

No plants using the process have been built in the United States. The European plants have been designed by Mr. Ruthner and differ from the one just described in several respects. One principal design difference is the use of an electric furnace in place of a direct-fired type. This substitution is made economically feasible by the low electric power rate and the high cost of fuel oil in Europe. Operation of European plants has verified the chemical feasibility of the process.

A number of chemical schemes have been suggested in the past for the recovery of by-products from waste pickle liquor. However, they have all been too expensive or have required the sale of chemicals for which there was a questionable market. These difficulties have prevented their widespread acceptance by the steel industry. We believe that this process has overcome these obstacles. The only by-product is pure iron oxide, which can be advantageously used at the steel mill.

The conversion of iron sulphate to sulphuric acid without the use of a sulphuric acid plant greatly reduces the capital and operating cost of the plant compared with other proposed recovery systems. Whereas it is usually expected that pickle liquor recovery processes must operate at a loss and are justified only as waste disposal methods, the process, under favorable conditions, will show a profit.

To illustrate the economics of the process, four engineering studies were made which are presented in Table I. A uniform basis was chosen for all four studies so that a direct comparison could be made.

The capital cost figure includes all costs for design and erection of the plant. Fixed charges include amortization of the total plant cost on a 10-year basis and percentage allowances for maintenance, insurance, taxes, and interest.

Utility requirements were calculated for each case. Utility expense was based on the following unit cost:

Cooling water	@	$0.04/1000 gal
Steam	@	0.50/1000 lb
Power	@	0.01/kw
Fuel oil	@	0.10/gal

The only raw material used in normal plant operation is makeup HCl. Since the degasser operates as an extractive distillation column, the makeup HCl can be added as muriatic acid and a price of 11¢ per pound of HCl has been used.

It is expected that one operator and one helper per shift will be needed to operate the plant. Operating labor costs are based on the following wage scale:

One operator	@	$2.00 per hour
One helper	@	$1.65 per hour

The two products of this process are recovered sulphuric acid and iron oxide, containing about 70 per cent iron. After taking a credit of $8.00 per ton for the recovered iron oxide, the net cost of the recovered acid is shown in the table.

Case I is based on a recovery plant capable of treating the waste pickle liquor from a steel plant normally using 10,000 tons per year of 60 degree Be′ sulphuric acid. It is assumed that 15 per cent of the total acid input to the pickling line is lost in the rinse water during pickling. Therefore, only 85 per cent of the acid delivered to the pickling line actually reaches the recovery plant as equivalent sulphuric acid. Of this quantity, about 98 per cent is recovered by the plant. It is further assumed that the waste pickle liquor will have a free acid concentration of 5.5 per cent and a ferrous sulphate concentration of 14 per cent expressed as $FeSO_4$. The cost of this plant, including erection, is $600,000. The plant is capable of recovering sulphuric acid at a cost of $35.40 per ton of 100 per cent acid, including all charges.

Case II was based on a recovery plant exactly twice the size of Case I. The erected cost of this plant is $1,050,000. The cost of recovering the acid in this plant is reduced to $31.80 per ton of 100 per cent sulphuric acid, due to the economics effected in building a larger plant.

Recently, there has been considerable interest in the use of high acid pickling. For this reason, two studies were made based on the use of high acid pickling for plants that would pickle the same quantity of steel as the examples used in the first two studies. It is assumed that with the use of high acid pickling, the waste pickle liquor will contain 25 per cent free acid and 14 per cent ferrous sulphate, expressed as $FeSO_4$. The capacity figures for the 25 per cent acid are not entirely correct since pickling with a high free acid concentration in-

TABLE I

Free acid, per cent	5.5		25.0	
Capacity, thousand tons per year	10	20	10	20
Capital, thousand $	600	1050	630	1100
Fixed charges $	317	553	333	580
Utilities	286	572	223	446
Raw materials	17	33	17	33
Labor	88	127	88	127
Total $	708	1285	661	1186
Recovered acid, $ per ton	35.40	31.80	14.05	12.50

creases the acid consumption considerably. However, the annual capacity figures of 10,000 and 20,000 tons per year of 60 degree Be′ sulphuric acid have been used to indicate that the amount of steel pickled is the same as the first two studies.

Case III is based on a plant operating on high acid pickling and pickling the same amount of steel as Case I. The erected cost of this plant is $630,000 and sulphuric acid may be recovered at a cost of $14.05 per ton of 100 per cent sulphuric acid.

Case IV is based on a plant operating on high acid pickling and pickling the same quantity of steel as Case II. The capital cost of this plant is $1,100,000 and the recovered acid cost is $12.50 per ton of 100 per cent sulphuric acid.

It should be noted that although the economics are improved by doubling the capacity, this increase is not nearly so pronounced as the improvement affected by increasing the free acid concentration in the waste pickle liquor feed. The marked reduction in cost of recovered acid when operating at high free acid concentrations is due only in part to a decrease in the evaporation load. The major reduction in cost is due to the fact that it eliminates the necessity for recirculating recovered acid to dilute the feed so that full credit may be taken for all of the recovered acid produced in the plant.

The advantages of high acid pickling have been known for a number of years. Dr. Edwin D. Martin of Inland Steel Co. conducted extensive investigations on chemistry of high acid pickling. A discussion of Dr. Martin's work is not within the scope of this paper. However, it might be well to summarize his conclusions. He found that the speed of pickling could be greatly increased and that this rate was independent of the iron concentration. These characteristics permit a much larger throughput of steel in existing picklers and permits the design of smaller units for new picklers, conserving valuable floor space. High acid pickling has not been used by many steel companies due to the fact that it increases the acid consumption when no recovery is used and also increases the disposal problem when neutralization is used as a waste treatment. However, this recovery process makes possible all the inherent advantages of high acid pickling, recovers acid at a practical cost, and eliminates the waste disposal problems.

In conclusion, the principal advantages of the process may be summarized as follows:

1. The entire sulphate equivalent of the waste pickle liquor is recovered as reusable sulphuric acid without the use of a contact or chamber sulphuric acid plant.
2. The only by-product obtained is iron oxide, which is practically pure and, when sintered, can be recharged to the blast furnace. It may possibly find use as a paint pigment or as a base material for making powdered iron.
3. Since substantially all acid in the waste pickle liquor is recovered, the inherent advantages of high acid pickling can be economically realized for the first time.
4. Use of inhibitors in pickle liquor is common and in many instances is a substantial operating expense. A portion of these inhibitors is returned with the recovered acid, thus reducing the consumption of inhibitors.

AISE

WEST COAST MEETING

Hotel Statler

Los Angeles, California

February 20, 21, 22, 1956

Make Your Reservations Early

Figure 1 — Camera is mounted to pick up picture of pouring operation of a continuous casting process.

Application of Industrial Television to the steel industry

. . . . industrial television is a tool which will enable personnel to control operations much more easily than heretofore possible . . . . visual operation gives better control than any system of signals . . . . manpower requirements can be reduced, bad temperature conditions and hazardous locations can be avoided . . . .

By JOHN MACALLA

Field Engineer, Diamond Power Specialty Corp., Lancaster, Ohio.

▲ TELEVISION is steadily gaining popularity as a control instrument in all types of steel producing and associated industries. More and more, engineers and supervisors alike are coming to rely on the benefits of remote vision to allow them more efficient and exact control of the widespread interdependent processes typical to the manufacture of steel.

Wire, closed circuit, or industrial television, more popularly known by the initials ITV, facilitates centralized control by allowing a viewer to literally be in two places at once. The resulting visual supervision often accomplishes as much as an actual visit to any scene in question. Along with its use as a control instrument, television is a valuable research tool. A television camera can be located in a hazardous or physically uncomfortable position with only a minimum of the protection demanded for a human observer. A picture of conditions taken from such a vantage point will often allow one or a group of engineers to better appraise the effects of heretofore hidden locations.

ITV too has a place as an interplant communication medium. Its use enables conferences or meetings to be held without the necessity of having the participants leave their respective areas. Adding sight to vocal contact brings to a group meeting a sense of realism second only to personal contact. Secondly, closed circuit television represents to a training supervisor an excellent means of promoting on the job training lectures. Television's main benefit in this respect is that it enables "live" pictures to be brought to a group meeting when they can be discussed in detail. Properly directed, the television camera concentrates the viewer's attention to the most important portions of a scene.

The theoretical uses of wired television need only an unbounded imagination to be fully explored. Most important however, are the many tangible installations existing as proven reality. The application of closed circuit television to the steel industry, followed closely on the heels of its first use as a tool in the utility field. ITV was first applied in the U. S. in 1946 as a means for allowing power engineers a fail-safe check on their water level. Then in 1948, established as an industrial

instrument, wired television was applied to a control problem of the Babcock & Wilcox Co.'s Beaver Falls Plant.

Here the application centered around a continuous casting pilot plant. In this process, the central control operator must keep a steady supply of liquid steel feeding to the forming chamber. In addition, he must know that the surface of the molten metal is free of foreign matter and that it carries a negative meniscus, a condition indicating proper mold temperature.

The camera in this case (Figure 1) was equipped with a long focal length lens, and surrounded by an air cooled housing to protect it from the intense heat. Mounted directly over the primary chamber, it allowed the operator a close-up view of the pouring operation particular to that area (Figure 2). At the central control pulpit, without TV the operator was unable to make adjustments necessary in the pouring operation except through the arm signals from a second observer. In addition to a savings in manpower, the ITV system eliminated a potential safety hazard, and very importantly lessened the chances of human error which may have occurred through misinterpretation of signals.

Television currently finds its most popular use in hot strip fabrication. In the forward portion of a hot strip mill, ITV cameras are assisting in the slab reheating operation. A typical example of this exists at the Fairless plant of the U. S. Steel Corp. (Figure 3). Here a slab operator is located (Figure 4) in a pulpit over slabs entering the central units. Cameras, mounted outboard of the pulpit, allow him a view of the slab charging line relative to the sides of the two flanking furnaces. On two monitors, every movement of the slabs are plainly visible to him permitting rapid alinement to be made from this central position. Because of television, there is no need for the operator to depend on a second observer in order to exercise his responsibility.

The second area of television usage in a strip mill deals with the control of hot strip runout tables. As a hot slab progresses through the rolling process, disturbances created by uneven screw-down pressure may cause

Figure 2 — Picture of pouring operation is shown on screen on operator's control panel.

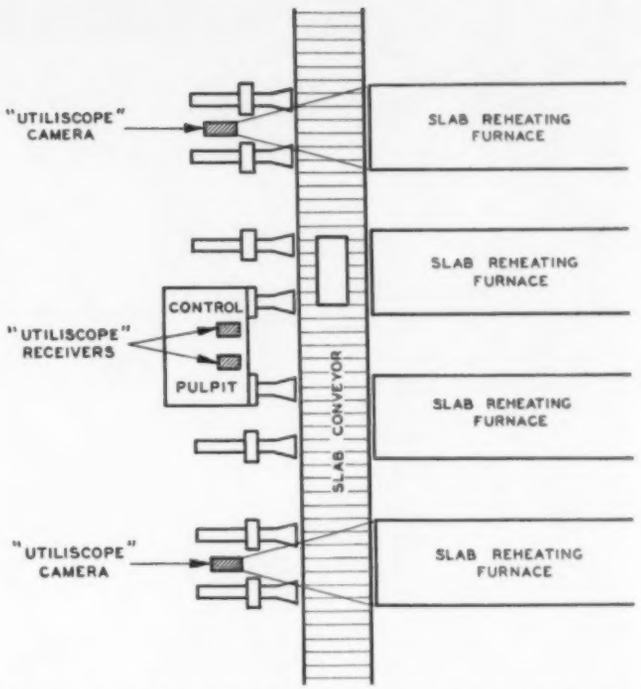


Figure 3 — Schematic diagram shows slab control positioning by ITV.

Figure 4 — Slab positioning operator in control pulpit checks alinement of slabs on two ITV monitors.

it to camber. This situation results in a hooked bar, which, when channeled into a coiler, results in either a time and material consuming "cobble" or more often in uneven coils which in later processing, represent a loss because of trimming.

To allow the mill operator an opportunity to see the condition of the bar as it enters the coiler, a television camera mounted in the roof trusses, (Figure 5) and directly above the coiler guides, transmits a picture of

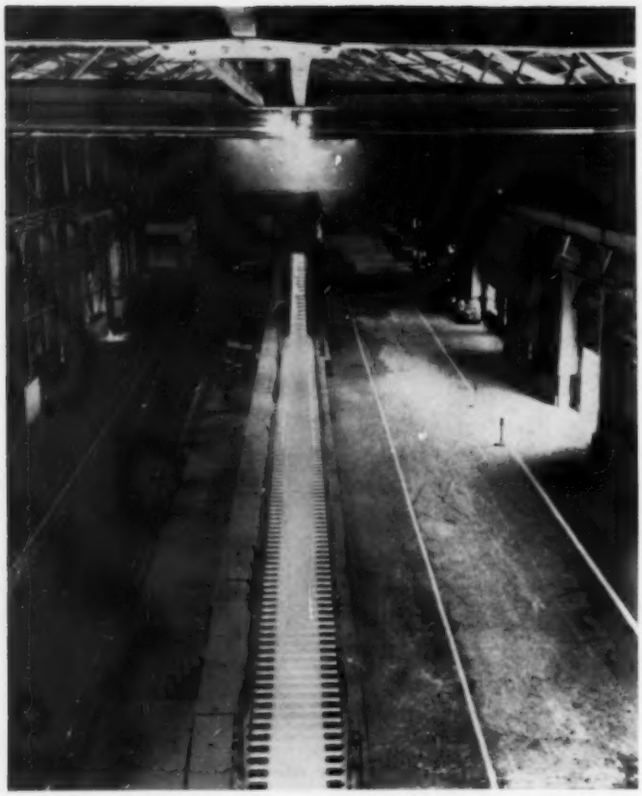


Figure 5 — View shows hot strip run-out table from camera position.

Figure 6 — Image of hot bar is given on monitor screen at screwdown operator's position.

the bar to the head rollers station. On a ten inch monitor screen, (Figure 6) he sees a picture of the bar after it has passed beyond the water sprays, progressing toward the coiler guide. Noting any camber, he can make necessary adjustments to his screw-down control which allows him to correct for misalinement of the strip. In this manner, he is able to make adjustments in his mill so that successive bars may enter the coiler squarely, minimizing scrap and preventing costly delays.

Industrial television, has also been applied with great success to the control of material moving through automatic furnaces. Figure 7 shows a portion of a furnace interior, in which steel tubes 20 to 30 feet in length are being moved by a walking beam conveyor. Supervision of this process, is a desirable feature. Should any of these tubes become misalined, their projecting ends would cause expensive damage to the refractory walls. Prior to the installation of ITV equipment, this operation when monitored required that a man be stationed near a viewing port, which because of the high temperatures proved to be very impractical.

At present, from a television camera (Figure 8) protected by a water jacket and viewing through an air cooled window, a picture is transmitted back to a central control pulpit where a single operator controlling the entire process line is located. Should he spot any disturbance in his system, he can immediately take corrective action. It should be noted that in this particular installation, a second TV camera is employed to monitor

Figure 7 — Interior view of automatic furnace shows position of tubes on walking beam conveyor.

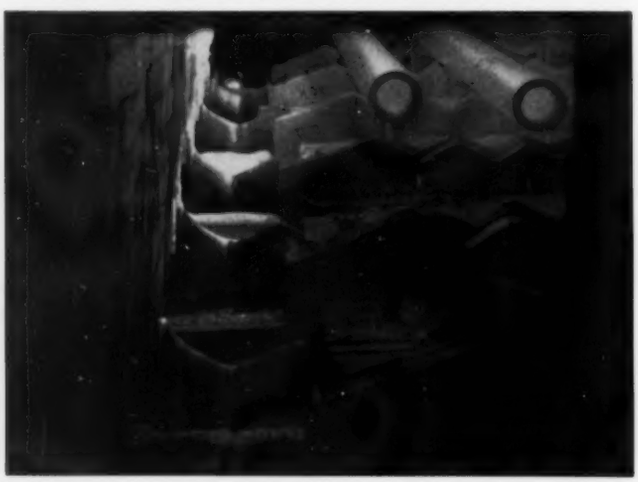
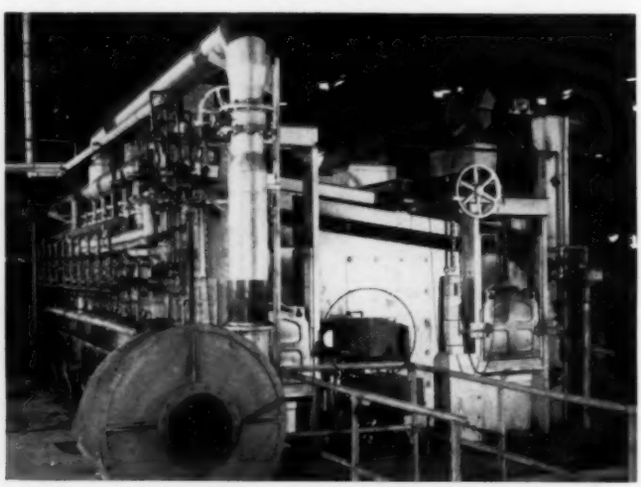


Figure 8 — Camera, enclosed in heat resistant housing, is positioned to view furnace interior.



the furnace interior of an annealing oven located further along in this same line. When this area must be observed, the operator, through a selector switch, connects to a second camera which allows him on his monitor screen to see tubes proceeding through the annealing process (Figure 9). Here again, all observations are made directly without dependence on any assistants.

Industrial television in each of these cases provides to the user savings through the reduction of operation and/or capital equipment costs. In addition, it allows supervisors and operators a more exacting check on their responsibilities without infringement on their safety. To properly evaluate these benefits, a survey should be made of the cost and problems involved in the installation and maintenance of equipment adapted to the rigors of steel mill operation.

Industrial television equipment, unlike its commercial predecessor, does in no way represent any great amount of complex equipment. Rather the design of wired television is based on four major points; simplicity, portability, low initial cost and capability of sustained operation without necessity of frequent readjustment. Typical equipment (Figure 10) may vary slightly in packaging. Two popular styles involve systems comprised of two or three components. In one, the observation station is divided into two components, the camera pick-up head and its associated power supply. In the second style, all of the observation and transmission functions are compacted into a single unit. With either design, the camera output is usually transmitted to the receiver by coaxial cable. Final selection of equipment packaging will vary with individual applications and will be based primarily on requirement of portability, equipment protection and accessibility.

Figure 9 — In control pulpit of tube processing line, monitor can be switched through selector to view either of two furnace interiors.

Figure 10 — Typical ITV equipment illustrates two and three component systems.

ITV circuitry is greatly simplified and designed with adequate safety factors. Despite this, the resulting picture is equal to and in many cases excels resolution qualities exhibited by standard television receivers. Keeping the number of tubes to a minimum reduces the probability of equipment failure. To facilitate speedy repair, when necessary, all components are of standard values making them easily obtainable from any well-stocked electronic supply house.

ITV systems require only a minimum of adjustment under sustained operation. Units are capable of operating within temperature ranges of 0 to 125 F, a figure extendable in some cases to 150 F. To protect against varying line voltages, transformer regulated power supplies assure operation despite fluctuations between 80 to 135 volts. Recent circuit developments also include an automatic electronic illumination control. This unique innovation allows the camera to adjust itself for changing scene illumination values within a range of 8 to 1. Without such a circuit, changes in light values with this range can cause an interruption to the picture, unless manual compensation is introduced.

For industrial purposes, generally all signal information is transmitted on simple video frequencies, which are relatively immune to external electrical disturbances. The output of each camera is sufficient to power at least eight stations without any modification, a feature of benefit when the same picture must be transmitted to many locations. In other cases where one control center must be used to view several different remote locations, any number of cameras can be switched into a single monitor.

From an economic standpoint, ITV systems are within practical limitations. The cost of a dependable system, consisting of a camera station, lens, receiving station and approximately 200 ft of interconnecting cable, will generally fall within a $2700 to $3700 price range. Provisions for periodic or preventive maintenance should be included in consideration of a system. This cost, allowing for the replacement of a relatively expensive camera tube, should fall within a range of $750 per year, per set of equipment; a unit cost subject to decrease as additional equipment is installed.

Final cost of a system will depend on the complexity of the individual application. Accessory equipment and

in particular illumination requirements, will vary sufficiently to make their cost difficult to predict. However, in general the total cost even when based on a single year will evolve to a low cost per hour of operation.

To achieve the best results from an ITV system, proper attention must be given to good engineering practice in initial installations. Steel mill service usually entails three basic problems, heat, contaminated atmospheres and illumination requirements. To properly provide for these conditions, an application must first start with the proper selection of camera pick-up tubes. Currently two types are available, a photo conductor tube and the image dissector (Figure 11). The dissector with the longest record of service is noteworthy from its cold cathode construction. This feature allows it a guarantee of 8950 hours of operation with a potential life expectancy of approximately 15 years. In addition to a photo surface most sensitive to the infra-red region of the spectrum, the electrical operation of the dissector is not particularly hampered by high temperature (200 F). Thus it is particularly useful in applications involving the remote observations of flame or incandescent objects. The image dissector, however, is limited in its general application because of its low response to light and its resolution capabilities, both of which are interdependent. Normally with respect to visible light, the dissector requires that 300 foot candles be directed on the area to be viewed. The impracticalities of this value, especially when large areas are in question, can easily be seen.

Allowing more practical illumination consideration, is the photo conductor tube, the newest of available camera tubes. Small (6 inches long by one inch in diameter) in size, this tube can create a picture of 500 horizontal lines. This may be contrasted to the normal value of 350 lines typical of pictures displayed in home television receivers. The photo conductor tube, although limited in life by an incandescent filament construction, may be considered to be good for over 5000 hours of operation. With it, optimum picture quality can be established with about 50 foot candles of illumination. Usable pictures, particularly of scenes involving little motion however, may be achieved with as little as five-foot candles of light. This tube is most sensitive to light in the blue-green portion of the spectrum (4800 angstroms). This, and the fact that it is a storage tube allows it to be used successfully with mercury vapor lighting.

Going from the selection of equipment, the next consideration centers around the use of suitable accessories to assure proper protection of components. Of first thought, is protection against dirt and mill scale.

Electronic equipment of any type is susceptible to disturbances generated by electrically conductive dust. In addition, the optics of the camera are hampered by dust of any type. Usually the equipment manufacturer can supply special housings complete with filtered air supplies for maintaining a clear surrounding atmosphere to both the observation and reproducing components of a system. As a good practice, it is advisable to have this protection checked and supplemented when necessary by a regular program of periodic maintenance.

ITV equipment requires protection from heat. In addition to possible carbonization resulting from prolonged exposure to high temperature, cameras employing photo conductive tubes assume electrical characteristics that make them inoperative at temperatures in excess of 120 F. Heat may be dissipated successfully through the use of filtered air. When it becomes necessary to augment this arrangement, a simple enclosure through which water may be circulated can be constructed so as to surround the sides and base plate of the camera.

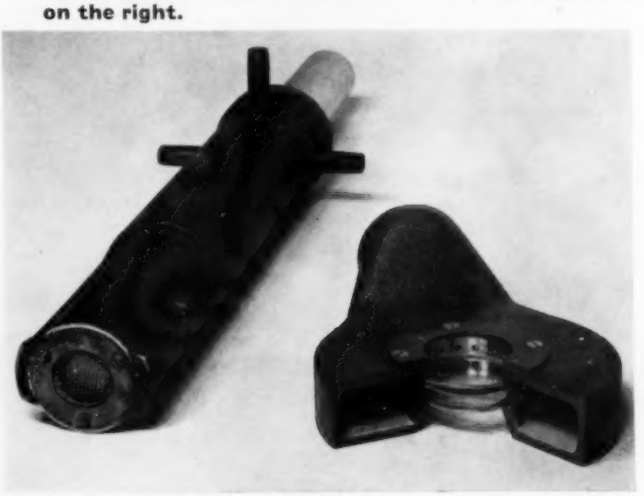
Figure 11 — Two camera pick-up tubes are the image dissector on top and photo conductor tube on right.

Many times specialized accessory equipment is required to allow the operation of ITV equipment under extraordinary conditions. Specialized furnace viewing accessories such as the air cooled window and the extended image lens tube (Figure 12) are typical of these requirements. The air cooled window, shown in cutaway form, consists of a chamber through which a stream of air passes against the high temperature area. Camera viewing is allowed by a window located in the center of the assembly. This window consists of a sheet of special glass, coated with heat reflecting surface, separated about 2 inches from a stainless steel screen.

In operation, air piped to the window is directed by the glass through the screen and against the furnace interior. This type of viewing has offered satisfactory service against contaminated areas involving temperatures of up to 2100 F.

The extended image lens tube also finds great application in flame observation work. Often when viewing a furnace, it is desirable to view as much of the interior as possible, a fact often complicated by thick refractory walls. The lens tube, consisting of an optical system

Figure 12 — ITV accessories enable camera observation of high temperature areas. Extended image lens tube and housing are on the left and air cooled window is on the right.



36 in. in length by 3 in. in diameter, is designed to fit into an air and water cooled sheath. This entire assembly may then be inserted into an opening 4 in. in diameter. Despite the small diameter, this assembly inserted through a furnace wall will allow a camera to take in a 52 degree viewing angle. By properly controlling the flow of water through the cooling chamber, the lens tube can be exposed to temperatures of approximately 2900 F.

Finally, after equipment and accessory selection has been completed, a last consideration should be observed in installing the ITV system. Care should be taken to provide reasonable access to the various system components. Doing this will facilitate periodic maintenance, a consideration proven by statistics to be successful in working installations. This care, it should be pointed out, is usually restricted to assuring general cleanliness of equipment and in particular to that of optical elements involved.

The extent of the acceptance of industrial television by the steel industry is shown by the duplication of many of the existing installations, described in the earliest sections of this paper. Added to these are several new uses, the most interesting of which are two installations involving the observation of incandescent materials.

The first of these deals with the observation of the interior of a model open hearth furnace. At the training center, employed to instruct operators in new combustion control procedures, a television camera is so positioned as to allow a picture of flame conditions. Through the manipulation of various combustion controls, flame characteristics can be varied over a full range. These changes displayed on the monitor screen located at the control panel can instantly be observed thus providing operators with a greater sense of assurance in their work.

The second new application deals with a control of skelp used in the manufacture of butt welded pipe. Such a process demands that observation be established over skelp edge-heating as it emerges from a continuous furnace. Normally, the control operator positioned to view this point, can clearly see only one edge. Soon, from the vantage point of a TV camera located directly over this area, the operator of an eastern pipe mill will be able to see sharply on a monitor screen, a clear representation of the heating process on both edges. The picture, generated by a tube sensitive to infra-red radiations, shows the edges as bright bands contrasting sharply to the relatively cool center body of the skelp.

These new installations of industrial television together with those already established, will soon provide additional evidence as to the worthiness of this remote control instrument. As it is given an opportunity to perform in more and more locations, the worth of ITV will become better understood. Ultimately, its use will be restricted only by the needs of the steel industry and the imagination of its engineers.

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By A. H. ANDREWS
Special Engineer
Construction Engineering Dept.
Bethlehem Steel Co.
Bethlehem, Pa.

. . . . material handling in the steel plant is an enormous job . . . . extremely high tonnages are involved, distances are great, intermittent operation as a result of a winter shutdown requires storage and adverse weather conditions must be met . . . . conveyor belts are being recognized as a most satisfactory and economical method for moving the large tonnages of bulk material involved . . . . flexibility of operation may be necessary, and other operations such as weighing or removal of contaminants are often combined with the material handling operation . . . . speed and economy are prime requirements . . . .

▲ THIS paper covers a few of the more interesting recent installations handling ore and coal in Bethlehem plants, indicating what some of the problems are and some of the methods of overcoming these difficulties.

The first use of belt conveyors as means of transporting bulk materials occurred about 1865 when Lyster, an English engineer, developed an endless belt of two plies of canvas with a rubber facing. About 1890 Thomas A. Edison also did some experimental work with flight conveyors handling ore, and adapted belt conveyors to ore handling, with continuous skirt boards along the belt to prevent the load rolling off the belt. Thomas Robins, about 1890, did considerable experimental work with idlers, and invented the three-pulley troughing idler, improved on the lubricating system for idlers, and developed new types of belts.

From that period to the present there have been constant improvement and refinement of the design of belt conveyors, and applications of the belt to the overall handling systems for many bulk materials. In steel plants today, belt conveyors of many types handle ore, coal, limestone, sand, bulk refractory materials, coke, flue dust, sinter, and many other materials. Belt conveyors in many cases are the most economical means of transporting large volumes of bulk materials. In conjunction with stackers, bridge cranes, mobile equipment (bulldozers, trucks, etc.), and various types of feeders, belts can be incorporated into systems of amazing flexibility and tremendous capacities, covering great distances with long life and low per-ton operating cost. Such a system is the new ore handling operation at Lackawanna.

LACKAWANNA ORE HANDLING SYSTEM

When the ore yard at Lackawanna was designed about fifty years ago, it was adequate to handle and store enough raw materials to feed blast furnaces making 4800 tons of iron per day. Today, the capacity of Lackawanna's seven blast furnaces is about double that figure. The ore is supplied from the upper Great Lakes region and carried by lake boat to Lackawanna docks during the lake season of April through November (Figure 1). The ore is unloaded by Hulett unloaders and deposited in the ore field immediately behind the unloaders (Figure 2). Bridge cranes distribute the ore in the field which is about 280 by 3900 ft with a capacity of 2,500,000 tons. In addition to ore, other raw materials such as dolomite and limestone are stored in the field.

As the capacity of the plant increased during the last ten years or so, it became necessary to store ore at other locations in order to last through the winter. The ore field could not be extended because the plant had

grown around it. When the seventh blast furnace was planned, additional storage area for raw materials was necessarily a part of the project, so that the extra handling connected with auxiliary storage areas could be eliminated.

Considerable study preceded the final decision on building a new ore storage field. The ore could be moved to the new field from the present unloading dock by conventional trucks or by mobile earth moving equipment, or by conveyor belt, or a new unloading dock could be constructed with an adjacent field for storage. Careful analysis and comparison of the cost of installation, cost of operation, and advantages and disadvantages of operation of the various handling methods resulted in a choice of the conveyor belt to move the ore from the present unloading deck to the site of a new storage field. A tripper and stacker would discharge the ore from the belt, and a new ore bridge with 13-ton bucket would distribute ore in the field and reclaim ore from storage.

The new storage field with a capacity of 1,500,000 tons is located parallel to and just west of the present coal storage area. Three long conveyor belts, 60 in. wide, form the ore stocking system, No. 1, 1260 ft long, running under the Hulett unloaders toward the south, No. 2, 1700 ft long, (Figure 3) running west to a point beyond the coal storage area, and No. 3, 2080 ft long, running north, parallel and between the coal storage and the new ore storage field. This conveyor system was designed to handle a maximum of 5,000 tons of ore per hour on belts traveling about 500 fpm. This maximum rate might be attained when the four unloaders worked at one time with free digging condition in a boat.

Ore unloaded from boats by the unloaders may go directly to the old storage area, to the new storage field via the new conveyor system, or the ore as it leaves No. 1 belt may be diverted to No. 5 belt, which discharges into storage bins above the blast furnace trestle.

In reclaiming, the bridge crane picks up 13-tons of ore and drops it in a traveling reclaim hopper which feeds it onto No. 3 belt. Belt No. 3, now running towards the south, deposits the ore on a transfer belt which feeds onto belt No. 2, now running eastward. Belt No. 2 feeds onto belt No. 5, which carries the ore up to eight 1000-ton capacity storage bins above the blast furnace trestle. Ore then feeds into blast furnace transfer cars, or onto screens, and into crushers to prepare ore for sintering plant consumption. Reclaiming capacity is about 1,200 tons per hour.

A few of the factors which had to be considered in planning such a handling system were these:

1. Some of the lake ores delivered to this plant by lake boat are very plastic and sticky, like clay. When mined, these ores are not too sticky, but upon exposure to rains or snows, they absorb moisture and may rise to as much as 20 to 22 per cent moisture. This is especially bad when the alumina (Al_2O_3) is also higher than usual, or 2 to 2½ per cent. These two constituents make ore plastic and sticky, and hence hard to handle.

   It sticks to hopper cars, it sticks to belts and

Figure 1 — General view shows ore dock and canal looking north.

Figure 2 — At ore docks, S. S. Johnstown is being unloaded by Hulett unloader.

Figure 3 — No. 1 and 2 ore conveyor belts are shown looking west. They travel at 500 fpm.

builds up on idlers and pulleys, it sticks in chutes. It is difficult to screen a sticky ore, also. Many variations in designs of screens have been tried in order to obtain a free flow of sticky material. Screens heated by electricity have proven to be helpful in some cases. A plate with oblong or rectangular slots is sometimes used to screen sticky ore, as are vibrating screens of woven wire mesh.

Sticky ores require a very thorough system of belt cleaners to remove the ore from the carrying side of the belt. Some types of cleaners use a piece of belt as the contact part of a scraper which is spring loaded, or has some other device to press the scraper against the belt. Drop chutes must be provided to return scraped ore to the main conveyor system. One mine conveyor system in Mesabi range uses a high pressure water spray to clean a belt just beyond the head pulley, however, such a system would require a sump and other drainage and ore separation facilities. Trouble with freezing weather could also be expected.

Another factor of considerable importance in keeping belts clean is the speed of the belt, since the centrifugal force as the belt goes around the head pulley varies with the square of the belt speed.

2. Ore weighs 150 to 180 lb per cu ft, and some of it is in the form of large chunks having sharp corners and edges. The problem of preventing excessive wear of the main belts due to such ore was given due consideration.

   The ideal condition for depositing ore on a conveyor belt would be to project it parallel to and just above the surface of the belt and at about the same surface speed as the belt. Since the main belts of Lackawanna's system traveled at about 500 fpm this was not practicable. In order to feed ore onto the No. 1 belt with the four unloaders at a steady rate so that the belt would be kept full, but not overloaded, each unloader has a 50-ton hopper with a disc or circular plate feeder in the bottom which drops the ore onto a traveling apron feeder, which is down close to No. 1 belt, at ground level. Thus a steady flow of ore from the circular plate feeder is deposited on the apron feeder which spreads it evenly on the No. 1 dock belt. Four unloaders thus deposit four thin layers of ore on No. 1 belt at minimum stress.

   In order to minimize a cutting action of the sharp chunks of ore, and to absorb some of the shock of the heavy ore falling onto the belt, the idlers supporting the belt at the dock side are special impact idlers spaced at 2-ft centers (Figure 4). This style idler cushions the belt and results in increased life of the long expensive No. 1 dock belt.

3. At transfer points where the direction of flow of the ore is changed, a transfer belt is used to change the direction and accelerate the ore at least partly to the speed of the next belt. The ore leaving No. 1 belt falls into a chute built with manganese steel wearing plates, and designed to obtain a maximum slope so that ore will not stick and pile up. Falling through the chute, the ore lands on the transfer belt which runs just above and parallel to No. 2 belt, the next main belt. The speed of the transfer belt is about 375 fpm, while the speed of No. 2 belt is about 500 fpm. At the point where the ore falls onto the transfer belts and onto all other main belts in the system, impact idlers are used to absorb the shock.

   A transfer belt is also used at the discharge end of No. 2 belt, to change the direction of flow 90 degrees, to coincide with No. 3 belt, which runs along the edge of the new ore field.

Figure 4 — Idler rollers on the conveyor gives extra belt life.

4. Of major concern in planning the Lackawanna ore handling system was the effect of cold weather on the handling methods and equipment. Temperatures of 15 to 20 degrees below zero occur occasionally, and winds up to 60 to 70 mph are not unusual. On the eastern end of Lake Erie, winter weather, generally speaking, is rather severe. Faced with such conditions, the designers placed wind guards on the west side of No. 1 and No. 3 belts, where, due to traveling hoppers or tripper and stacker, it was not possible to house the belt. Part of No. 1 and all of No. 2 and No. 5 belts are housed in galleries.

   Considerable study was made of belt conveyor systems in the Mesabi Range in Minnesota, in connection with cold weather operation and high tonnage rates, and trouble at transfer points. Most outdoor conveyor and mining operations there are idle from about December first to April fifteenth. The maximum capacity belt observed there was 1500 tons per hour.

   The frozen condition of ore in the field during most of the winter was one of the main reasons for choosing an ore bridge crane with heavy bucket for reclaiming instead of bull dozing to crawler cranes for handling back onto the No. 3 belt. A bridge crane is retarded very little by the frozen crust of the ore field, while bull dozers may have considerable trouble.

Other interesting features of this ore handling system are these:

1. There are three main drive stations for the conveyor system, at each of which there are 440-volt step-down transformers. Power is transmitted at 13.8 kv through 3-phase cable, carried at each of the three drive stations.
2. Heat is provided at each of the main transfer points in order to minimize the danger of freeze-ups during winter.
3. The system functions very well in handling limestone or dolomite from self-unloader lake boats (Figure 5).
4. Further flexibility of the system is attained by unloading coal from lake boats. The stacker and tripper on No. 3 belt can be swung to discharge to the east of No. 3 belt, which is the coal storage area.
5. In order to maintain proper tension in the belts, there are take-ups on each main belt with counterweights in towers, and provision for a 30-ft take-up on the length of each of the three main belts. When starting these belts, the take-up gives as much as 15 ft, due to stretch of the belt under starting load.
6. A herringbone design of lagging on the rubber covered head pulleys provides maximum traction for the belts and assists in keeping head pulley clear of ore.

Figure 5 — Self unloading boat unloads dolomite into hopper on No. 1 conveyor belt.

LACKAWANNA'S COAL HANDLING SYSTEM

In January of 1953, at Lackawanna's high volatile coal storage field, a bad storm with high winds off Lake Erie blew the old coal bridge into a skew of 15 degrees, and finally under pressure of bad wind gusts, it collapsed. Since this bridge was the only one serving the high volatile coal field, emergency measures were necessary to reclaim coal for the coke ovens. A 36-in. reversible conveyor belt ran the length of the coal field (2500-ft), connecting with the old bridge, for stocking and reclaiming. This belt was elevated about 25 ft above ground level and was carried in a covered gallery. At the point where the falling ore bridge crushed the gallery, the belt was reset to ground level as a temporary setup with a hopper for reclaiming (Figure 6). A bulldozer and caterpillar crane was used to reclaim to this hopper from the field.

When the bridge was lost, immediate studies were undertaken to determine the nature of the new coal handling facilities, whether the bridge would be replaced, or whether mobile equipment would be preferred. The study necessarily covered: (1) the 1953 coal handling requirements, (2) modernizing the coal handling and preparation facilities, (3) the requirements of the future plant, expanded to optimum capacity. Presently seven batteries of coke ovens are in operation, consuming about 9200 tons of coal per day. The future coke plant might total ultimately 11 or 12 batteries, consuming 17,000 to 18,000 tons of coal per day. It was decided that a belt conveyor system with mobile units for spreading high volatile coal in stock, and mobile units for reclaiming to belts would be much more flexible, and could serve a greater area, and would provide more capacity than the coal bridge with its 500-ton per hour capacity, Also, better blending in stock of the various high volatile coals would be obtained. This point is very important to the operation of coke ovens and the blast furnaces. Also, such a handling system could readily be expanded as batteries are added in the future.

All coal in recent years has been delivered to Lackawanna in railroad cars which are dumped by a car dumper (Figure 7). A belt conveyor system carries the low volatile coal out to a tripper and stacker, where a caterpillar crane and bulldozers spread it out in a storage area. Reclaiming is effected by the same belt which is reversible, with the crane feeding a traveling reclaim hopper straddling the belt.

Inadequate conveyor capacity to move coal away from the car dumper to the storage field has limited

Figure 6 — Temporary setup for handling coal was made up using a caterpillar crane and hopper. The belt was reset to ground level.

the operation of the whole coal stocking system to about 8 cars per hour, or 500 tons per hour, or 800 tons per hour direct to breakers and coal preparation. The new belt conveyor system was planned for the maximum dumping capacity of the car dumper, 20 cars per hour, or 1400 tons per hour. The new belts are 54 in. wide, running at about 500 fpm, and the system is adequate to stock in two 8-hour shifts enough coal for a total of nine batteries or 12,750 tons per day, and reclaim the same amount during the same 16 hours.

In order to assure an adequate supply of coal for plant operations regardless of mine strikes, rail strikes, etc., it has been customary to store coal at the coke plant sufficient to operate for 45 to 60 days. This condition has been maintained by putting into storage and reclaiming each day enough to turn over the total tonnage stored within about six months, depending on the rate of deterioration of the coal. While this presents a tremendous problem in handling, a certain benefit has been obtained due to the blending of the various types of high volatile coal consumed.

During any one month, high volatile coal received at Lackawanna may come from as many as thirty different mines. These coals vary considerably in ash content, sulphur content, etc. It is necessary to smooth out these variations in order to produce satisfactory coke and to prevent excessive damage to oven brick work. Erratic coke oven operation is expensive, and the low quality product has a very bad effect on blast furnace operation. Hence, we cannot overemphasize the importance of adequate handling and blending facilities to properly store, mix and blend the various kinds of coal consumed.

One of the better ways of eliminating the variables in high volatile coals is to spread it out in thin horizontal layers on the ground in storage, and reclaim by taking vertical cuts through the several layers. After "breaking" this coal in a rotary type breaker, it is well mixed with low volatile coal by careful weighing on a belt scale and feeding the two into a crushing operation. Storage of the prepared coal in bins ahead of the coke ovens is also of value in further mixing.

Figure 7 — Rotary car dumper handles all coal cars.

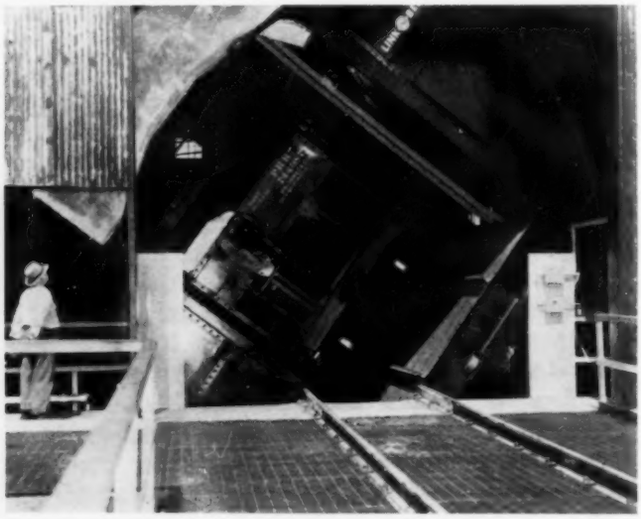
Figure 8 — Equipment developed for earth moving has been finding applications for handling raw materials.

Figure 9 — Tractors with scrapers are used for hauls up to 800 ft.

The most economical way of spreading coal in thin layers in storage is through the use of mobile equipment, previously mentioned. Several types of movers are available, some of which are self-loading, and discharge from the bottom. One of the largest is the twin motor self-loading scraper wagon running on rubber tires (Figure 8) which, in tests at Lackawanna, has averaged 240 tons per hour reclaimed over a round trip of about 1200 to 1400 ft. For shorter hauls up to 800 ft, caterpillar tread tractors pulling 25-ton capacity rubber tired scraper wagons are more efficient (Figure 9).

It is estimated that Lackawanna needs four large bulldozers, two 25-yard scraper wagons, and two twin-engine scraper wagons for stocking and reclaiming

Figure 10 — A new rotary car dumper was installed at Steelton in 1953.



6,000 tons of high volatile coal in 16 hours per day. The ability of this equipment to move coal over greater distances and areas than a bridge crane will permit building up three separate piles of high volatile coal, each containing high volatile coal of a certain composition range, while blended coal is being reclaimed from three other similar piles.

In reclaiming with scraper wagons, ground level hoppers are strategically located to serve the storage area and will be connected by inclined conveyor belt to the main reclaim belt. The scraper wagon gathers a load of coal from the pile, drives over the grate of the hopper and dumps the coal. Such a system is flexible, fast, and can be readily expanded to the ultimate maximum capacity of the coal storage system.

An important factor in storing high volatile coal for months at a time is compaction, or packing the coal into a dense mass to exclude air and prevent spontaneous combustion. Loose coal weighs about 50 lb per cu ft, while packed coal may weigh up to 70 lb per cu ft. Large rubber tired mobile units obtain a more dense packing of coal than caterpillar tread units, according to tests and experience of companies who have been using mobile equipment for many years.

STEELTON CAR DUMPER AND ORE HANDLING

The Steelton plant operates three blast furnaces. Prior to 1953 all ore was dumped from hopper cars on a trestle and distributed in the adjacent ore field by a bridge crane. For reasons of economy and capacity, this was an unsatisfactory arrangement.

To correct this operation, a rotary car dumper was installed early in 1953 to dump cars of ore. (See Figure 10). A new conveyor belt system then carries the ore from the dumper out to the storage area. A tripper and stacker discharges the ore from the belt system in a pile at the edge of the field (Figure 11), and the ore bridge distributes the ore in storage.

The car dumper dumps ore from the car into three bins which feed onto these rotary plate feeders 10-ft in diameter (Figure 12). The ore is plowed from the feeders onto a 48-in. belt No. 1, which then feeds onto a second belt, No. 2, running across the end of the storage field. At another transfer point, the belt system turns along one side of the field and belt No. 3 runs the length of the field, which is 1900-ft long. The stacker and tripper on this long belt discharge the ore into the field.

The power to pull the conveyor belt and its load over the idlers is usually applied through the head pulley, or the pulley at the delivery end of the belt. A motor, driving through a gear reducer, drives the head pulley, and friction between the pulley and the belt drives the belt. There is a limit to the power that can be transmitted in this way, one factor being the area of contact between belt and pulley. Usually the idler next beyond the pulley can be so located that there is 200 to 220 degrees of contact between belt and pulley, thus increasing the traction area. A rubber belt running on a rubber covered pulley results in a 50 per cent increase in the coefficient of friction as compared to a rubber belt on a steel pulley. The herringbone lagging on the

Figure 11 — Conveyor belts take ore from dumper to storage area.

rubber covered head pulley helps to prevent ore sticking and building up on the pulley.

The construction of the heavy duty cord conveyor belt itself is an interesting development covering many years. Starting with plain canvas about 85 years ago, the belt is now a complex design meeting several requirements. The tensile requirements are provided in longitudinal cotton or nylon cords built into each ply of the carcass of the belt. There may be ten plies, or even more. These cords are embedded in rubber. On the bottom side of the carcass, one or two plies of heavy duck give transverse stability to the belt. Above the cord plies is the breaker strip, an open mesh fabric which binds the outer rubber covering to the carcass more firmly and resists any tearing action on the cover. The top rubber cover is at least $\frac{1}{16}$ in. thick and may be as heavy as $\frac{1}{2}$ in. thick. The bottom cover may be $\frac{1}{16}$ to $\frac{1}{4}$ in. thick, and it protects the belt carcass from damage by impact against idlers during loading and keeps dirt and moisture out of the carcass. The edges and both surfaces are rubber covered, and good maintenance practice requires that cuts and tears in the belt be vulcanized periodically to prevent dirt and moisture getting at the fabric in the carcass.

Figure 12 — Bins feed onto rotary plate feeders.

Sometimes a belt may be so long and the load so great that satisfactory driving traction is not attainable on one pulley. Under such circumstances, two head pulleys are used, with a separate motor drive and gear reducer for each pulley. This dual drive transmits power to the 1900-ft long belt No. 3, running the length of the ore field at Steelton.

The dual motor drive, is better than two geared pulleys driven by one large motor because the belt stretches some at each drive pulley. Since maximum pull should be at the first pulley, its rim must move slightly faster than the rim of the second pulley. The second pulley tends to become plastered with dirt from the carrying side of the belt, and this will upset the speed differential provided by a slightly smaller diameter, causing either a slippage of the belt on the second pulley, or an excessive load. The dual motor drive automatically adjusts the load on each pulley. The primary motor is started on reduced voltage with time limit acceleration through an automatic compensator. The secondary motor is a slip ring motor with a block of permanent resistance in the secondary circuit to insure fairly constant loading when running at full speed. The primary motor determines the acceleration and then maintains constant speed under all conditions of loading. The slip-ring motor automatically maintains a nearly constant horsepower output and adjusts itself to the speed variation and stretch of the belt, taking only its share of the load.

Figure 13 shows the impact idlers used at the various points in the system where ore falls onto a belt, such as under the rotary plate feeders and at the two main junction points. Spaced at 12-in. centers, these idlers help to lengthen the life of the expensive belts.

An item of considerable concern to the operators of this ore handling system was the probability of wet, sticky ore clogging the three bins directly under the car dumper. Steelton consumes lake ore which is shipped from the lower lake ports in hopper cars. These cars are occasionally exposed to periods of heavy rain which increases the moisture content to a point where the ore acts like a wet, sticky clay. Under such conditions, the car dumper is rotated only part way, so that about one-third of the carload is dumped into the three bins. Usually this small amount of ore will flow into the plate feeder, and when it has mostly passed through, the car dumper is rotated about 20 degrees further, so as to dump the second third of the car load. This interrupted dumping operation requires about four minutes per car. When this same ore is comparatively dry, cars are dumped in two minutes, without interrupting the dumping motion.

The ore is handled to the dumper in trains of about 12 to 15 cars by a diesel locomotive which pushes each loaded car into the dumper, thus bumping the empty car out of the dumper. The empty car runs down an inclined track and is accumulated with others for later handling. A crew of three men operate the locomotive, feeding cars to the dumper.

A foreman and five men take care of the operation of the car dumper and belt conveyor system, including the junction points where a man is required for cleanup and to clear any clogging or stoppages due to large

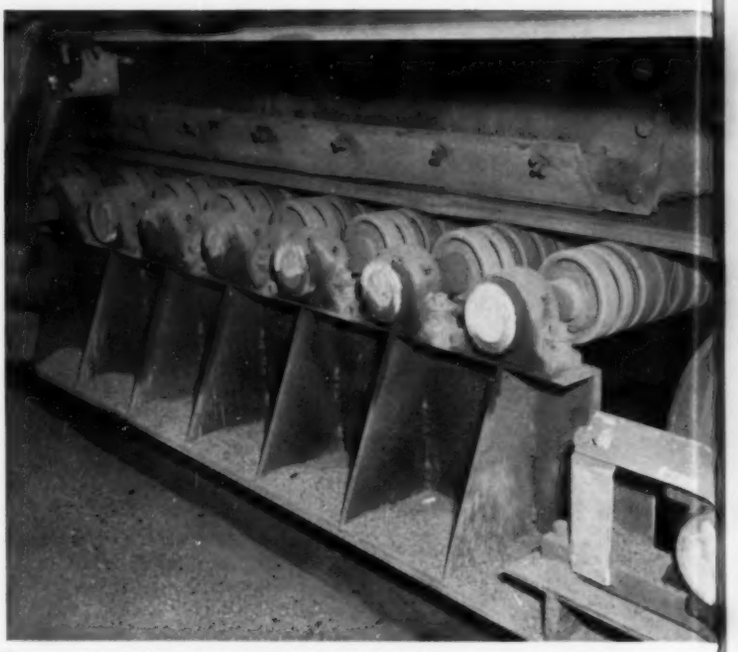


Figure 13 — Closely spaced impact idlers are used under the rotary plate feeders.

lumps of ore or pieces of wood. This also includes a man on the stacker which piles the ore at the edge of the storage field. This crew of six men with the car dumper and conveyor system now handles more material in one 8-hour shift than 24 to 30 men could unload from the trestle. Many of these materials, including the sticky type of ore, would not flow out of hopper cars and had to be dug and poked loose.

STEELTON COAL HANDLING AND STORAGE

Steelton consumes about 2500 tons of coal per day in two batteries of coke ovens. About 60 days supply, or 150,000 tons, is kept in storage, part of which is located under a rotary type coal bridge. The balance is located in a coal field adjacent to the bridge.

All coal is delivered in hopper cars on either of two tracks, both of which permit dumping into four track hoppers. (See Figure 14). Four apron feeders move the

Figure 14 — The rotary coal bridge at Steelton is an unusual design.

coal up to a belt which, with adjustable chutes, feeds the coal: (1) to a 36-in. reversible belt which carries the coal to the storage field, or (2) to a pocket where the bridge bucket can reach it for distribution under the rotary bridge, or (3) to a belt which carries the coal directly up to the breakers and crushers. The cars are moved into position for dumping by a cable pull. To facilitate dumping in cold weather, gas burners are used under the cars to loosen frozen coal.

The rotary or pivoted bridge crane is about 45 years old, and has a bucket which handles about 4 to 4½ tons of coal. This crane handles coal into storage and reclaims it when required. It is limited to the segment of circular area it covers, and thus this design is seldom used today.

There are two types of coal used at Steelton—high volatile and low volatile. A mixture of about two-thirds high volatile and one-third of low volatile results in good coking quality coal. In order to maintain a fairly accurate mix, care must be exercised in storing coals in separate piles.

In the field storage, a stacker belt discharges coal from the 36-in. reversible belt into a pile from which two bulldozers push it into storage. For reclaiming, a hopper at ground level receives coal pushed into it by the bulldozers. The hopper feeds onto an inclined belt which discharges onto the 36-in. reversible belt.

After the coal has passed through the rotary breakers, it is stored in four cylindrical bins, set above the mixing and crushing equipment. The four bins permit separation of the two types of coal used. These coals are fed out of the bins at a controlled rate, and mixed on a belt and fed into a chute which leads to the hammermill crushers. The mixed and crushed coal is then conveyed to the supply bins at the coke ovens.

BETHLEHEM COAL HANDLING

Bethlehem operates five batteries of coke ovens, the fifth battery being a 1953 addition. All coal is delivered in hopper cars, the monthly consumption of coal averaging about 210,000 tons. High volatile coal is about 65 per cent of the mix and low volatile is 35 per cent.

The cars of coal are pushed up an incline by a "mule" into a car dumper. The dumper empties the hopper car into a transfer car which moves to any one of seven hoppers set below the transfer tracks. Coal is thus segregated in these hoppers according to type, and proportioned out of these hoppers onto three collecting belts which move the coal up to the three breakers. After breaking, three table feeders are used to feed high and low volatile coal to the crushers, thus getting a desirable mixing action. About 70 to 85 per cent of the coal received in cars goes directly into the preparation and coking process, so that the cost of coke produced of handling coal into stock and reclaiming is low. The ability to mix and blend thoroughly permits consumption of this high percentage of coal directly from the car dumper.

The transfer car receiving coal from the car dumper also can move to another track hopper feeding onto a belt system used in moving coal into a new storage area. A third possibility is for the transfer car to move

Figure 15 — These 42-in. belts carry about 300 tons per hour.

further down the track and dump into a trench paralleling the tracks of a bridge crane. The crane then can distribute coal from the trench into the coal field straddled by the bridge, an area about 1000 by 250-ft. Bulldozers are used to push the coal beyond the reach of the crane and to reclaim within the reach of the crane.

The new storage area served by the new belt system includes two general areas, one of which receives coal from an inclined stationary stacker belt, and the other area receives coal from an "airplane" tripper which travels over a 900-ft 42-in. wide belt. (See Figure 15). These 42-in. belts travel about 400 fpm, and carry 300 tons per hour. Bulldozers and carryalls spread the coal into storage and reclaim it within reach of the bridge crane.

As mentioned previously, regular practice in receiv-

Figure 16 — At Sparrows Point all coal is delivered by barge or scow.

ing coal is to put about 70 to 85 per cent of coal into coal preparation and coking as dumped, so that only a small part of the total received goes into storage. What goes into storage is normally handled by the bridge crane. The conveyor stocking system is used for unusual situations which result in sudden influx of coal which can not be consumed and must be stored. A total of about 450,000 tons of coal is now held in storage at Bethlehem.

The importance of adequate blending of the several types of high volatile coals, and then the mixing of the high and low volatile coals is again emphasized at Bethlehem. The blending and mixing operation made possible by the handling facilities just described results in much longer life of the coke oven brick work, and results in consistent quality of coke which is very important to blast furnace operation.

SPARROWS POINT COAL HANDLING

Sparrows Point has ten batteries of coke ovens operating at present, which consume about 13,300 tons of coal per day. All coal is delivered by barge or scow and is unloaded by three bridge cranes (Figure 16). The bridges can place the coal into stock in the field that they span, or they can feed coal into a hopper on their dockside leg. The hoppers discharge automatically into small railway cars attached to a cable pull, which circles around the coal storage area, which is about 1500 ft long by 300 ft wide. The bottom dump cars discharge coal into a hopper at one end of the field. The hopper feeds onto two 42-in. conveyor belts which carry the coal up into four 400-ton bins feeding the breakers and coal crushing facilities.

These handling facilities were barely able to supply and prepare the coal needed by ten batteries. Relief was recently completed in the form of a conveyor belt system to place coal into the coal field northeast of the bridge cranes, and reclaiming facilities to feed coal up to the new breakers and crushing equipment. The new system will supply prepared coal to batteries No. 9-10-11, and the old system supplying batteries No. 1 to 8, inclusive. Arrangements have been made to expand the handling and preparation capacity when more batteries are added. Total coal in storage is now about 750,000 tons.

The present bridge cranes will continue to unload coal for the present coal handling system and for the new system. This will total 500,000 tons per month. The bridge, in feeding the new system, carries coal to the near end of the bridge and then drops it into one of the two traveling 90-ton hoppers in the foreground. The hoppers straddle and feed onto a 54-in. conveyor belt No. 2 which transfers the coal to the 48-in. belt conveyor No. 3 running into the foreground. This latter belt parallels the coal field which supplies batteries No. 9-10-11; it feeds coal to a belt 48-in. wide (No. 4) which terminates in a stacker. The stacker in Figure 17 deposits coal in the field where bulldozers and carryalls spread and pack it in storage. If so desired, coal can be conveyed directly to the breakers and crushers instead of going into the storage field. In this case coal discharged from conveyor No. 3 would not go to the stacker, but would be chuted to belt No. 5 leading up to the new breakers and new crushers.

Figure 17 — Stacker deposits coal, and earth moving equipment spreads and packs it for storage.

In reclaiming, carryalls will pick up a load of coal from storage and drive onto a grating covering two hoppers at ground level. These hoppers are located under the junction house supporting the stacker, as shown in Figure 17. From these two hoppers, the coal is fed onto conveyor No. 5 which leads up to the breakers and crushers.

JOHNSTOWN ORE HANDLING

Johnstown's seven blast furnaces produce pig iron from ore mined in the upper Great Lakes region. It is shipped by lake ore carriers and by rail to Johnstown where the cars are unloaded by a movable car dumper, the ore being placed in storage piles by three bridge cranes. A total of about 1,200,000 tons of ore may be stored here.

In reclaiming ore from the storage piles, the new 15-ton bridge drops bucket loads of ore into the hoppers in the right hand leg of the bridge. These hoppers when full are ready to discharge into one of four transfer cars running on two of the three tracks below the hoppers. The transfer car then travels to the far end of the storage field to the blast furnace stock bins, or to the track hoppers which feed belt conveyors leading to the sintering plant.

Much of the lake ore is a fine material, some of it like clay, which does not promote good blast furnace operation. The fine ore is therefore sintered with flue dust and other materials, producing a coarser product of much greater value to blast furnaces.

In early 1953 about 100,000 tons of ore per month was screened, about 60,000 tons of fines going to the sintering plant and 40,000 tons of coarse ore going directly to the blast furnaces. The screening operation (Figure 18) is presently being expanded so that about 180,000 tons of ore may be screened. The result will be a blast furnace ore burden with very little fine material.

The ore storage area is supplemented by a second ore field located near the lower works blast furnaces, in another part of the Johnstown plant. It has a capacity of about 800,000 tons of ore and is served by a

stationery car dumper, transfer cars and two bridge cranes.

As at other plants, limestone and dolomite are also stored in these two storage areas under bridge cranes in the same manner as ore is stored. They are handled by car dumper, bridge crane and transfer cars to the blast furnace stock bins.

SUMMARY

The preceding gives a rather brief glimpse of the methods and equipment used in Bethlehem plants in transporting and moving ore and coal and similar bulk materials. A review of some of the more conspicuous factors encountered in these material handling facilities is now in order.

1. *Greater tonnages*—The factor most likely to catch attention is the magnitude of the flow of material. When an ore field is described as having a capacity of 2,500,000 tons like Lackawanna's, usually the significance of the figure is lost. It might be better appreciated if we recall that this tonnage is delivered intermittently in batches by ships over about eight months of the year; that speed in unloading the ship is of importance, thus handling at highest possible tons per hour is important; that several different types of ore, plus limestone, dolomite, coke, sinter, etc., may be stored in this area, and must be kept in separate piles. Add to these factors the unpredictable weather and its effect on outdoor exposed machinery, plus the frequent demand for crushing or screening or sintering before the ore is finally put into the blast furnace, and then the 2,500,000 tons of ore presents quite a problem in movement.

Figure 18 — About 180,000 tons of ore a month are screened.

A great part of this paper has dealt with conveyor belt systems. We do not believe we have overestimated the importance of this device in moving bulk materials. Conveyor belts are more and more being recognized as the most satisfactory and most economical method of moving large tonnages of bulk materials. While a belt conveyor system does require great care in design, and usually requires some period of adjustment and regulation after installation, it is usually a low cost per ton method of moving material in great tonnages.

2. *Flexibility of systems*—Usually it is possible to design a material handling facility to serve more than one purpose, to handle more than one material, to be reversible, to serve as a mixing or blending device, or to serve as a measuring or weighing device. On many coal handling systems, magnets are placed so as to remove tramp iron from the flow of coal.

Conveyors often can be located overhead or underground, using waste space. Several types of coals are accurately weighed in modern coke plants, permitting a consistent blend of several variables.

In conjunction with various types of feeders, a very close control over the flow of materials is possible. This makes blending of coals to rather close tolerance quite simple. Circular plate feeders, apron type or pan type feeders, belt feeders, vibrating or oscillating feeders and drum feeders, all have their applications for certain materials or circumstances in order to obtain a constant flow with steady, even loading of the belt.

Flexibility is well demonstrated by Lackawanna's new ore conveyor system. It will handle ore at the rate of at least 5,000 tons per hour to the new storage area, or to the bins over the blast furnace trestle. If a self-unloading boat, delivering limestone or dolomite arrives, this material is also easily handled. If a boat discharges coal, the conveyor system handles it to the coal storage field adjacent to the new storage field. During winter when the lakes are frozen, the belts are reversed and ore or limestone is reclaimed from storage and moved up to the bins over the blast furnace trestle. This flexibility is attained by ingenious combinations of conveyor belts, mobile equipment, bridge cranes, caterpillar cranes and shovels, and various types of feeders.

3. *Speed of handling*—The various combinations of conveyeor belts, feeders, bridge cranes and mobile equipment observed in Bethlehem's plants are capable of moving bulk materials at rapid speeds. Many belts travel at 500 fpm, which is about six mphr. Some of the rubber tired mobile equipment travels at 35 mphr with a 25-ton load. The overall result is surprising when one remembers the tonnages involved may be 3000 to 5000 tons per hour.

4. *Economy of handling*—One of the prime aims in designing a large bulk handling system is economy, which includes a balance of economy of first cost,

economy of operation, and economy of maintenance and repairs. The life of the major components of such a system is very important, and for this reason a very heavy, rugged style of construction is noticeable in all steel plant construction. Detailed studies of the cost of various types of systems always precede the installation of handling facilities. These studies cover manpower required for operation, repair costs (including such items as replacing about 4000 ft of conveyor belt at about $40.00 per foot), cost of power required to drive the system, and frequency of replacing mobile equipment.

In conclusion, the efficiency with which materials are handled is a very important factor in the period of intense competition which the steel industry is experiencing. When a difference of $0.10 per ton of steel product may mean operating at a profit or a loss, the $0.10 differential may well be overcome by efficient handling of bulk materials. The emphasis of this subject has been very noticeable in recent years, as entire steel plants were built, or old ones were improved and expanded. The expansion of foreign mining properties and the handling facilities abroad and at U. S. eastern seaports for loading and unloading coal and ore has brought to attention many new applications of bulk handling principles. We feel that Bethlehem has at least kept pace with these developments.

DISCUSSION

PRESENTED BY

G. M. SHARER, Supervisor of Design, United States Steel Corp., Fairless Hills, Pa.

J. C. SCHAAKE, Chief Draftsman, Bethlehem Steel Co., Sparrows Point, Md.

H. W. POTTER, General Supervisor, Open Hearth Dept., Lukens Steel Co., Coatesville, Pa.

H. S. SPITZ, Chief Engineer, Homestead Works, United States Steel Corp., Munhall, Pa.

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

A. H. ANDREWS, Special Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

G. M. Sharer: There are several points which I would like to question in regard to the various materials handling problems discussed by Mr. Andrews, and one of the points is that the No. 2 conveyor at Lackawanna is reversible. I would be interested in knowing the length of the No. 2 conveyor and whether any difficulty has been experienced in training the belt to run in both directions.

One of the objections in designing long reversible belt conveyors close to the ground is to overcome the problem of take-up for slack belt. Either the counterweight would have to be exceptionally heavy to accommodate the slack belt on the tight side when operating in the reverse direction, or two take-ups would have to be provided, one on either side of the drive to accommodate the slack belt as the slack side tension varied with direction of belt. I would like to know how this problem was overcome at the Lackawanna Works on this particular conveyor.

We have found that in the handling of both wet and dry ores on the same conveyors, the wet ore is tenacious and adheres to the transfer chutes if chutes are not steep enough; or if the chutes are designed steeper, the dry lumpy ores wear them out in fast order. Have you experienced a similar problem, and if so, how was the problem overcome?

At Lackawanna, coal is handled to storage by mobile equipment, whereas at Johnstown coal is still being handled by bridges. I would be interested in learning how the cost of handling coal with mobile equipment at Lackawanna compares with cost of handling by bridge at Johnstown.

I have seen the circular coal bridge installation at Steelton and have wondered what the thinking was in such a design rather than the usual design of a bridge spanning a rectangular area where the storage area can be extended as required.

J. C. Schaake: When conveying ore in one direction, conveyors normally dump their ore from a high level to a low level conveyor. However, when the direction of the belts are reversed, what equipment is required to transfer the ore from the lower to the higher conveyor?

Also, does the speed of the belt or the size of the ores have any appreciable effect on the maximum incline of the conveyors?

H. W. Potter: I would like to ask Mr. Andrews how he heats frozen cars.

H. S. Spitz: I would like to ask Mr. Andrews what methods are used for weighing ore at Lackawanna, between the unloading operation and the storage field; and inasmuch as the problem is probably more important at Sparrows Point, what methods are used there for weighing incoming ore at point of unloading to the ore yard?

C. E. Pritchard: In Lackawanna, where you have extreme winter conditions to encounter, what method do you have for safeguarding or compensating for the ambient temperature conditions with regard to the operation of the equipment, such as lubrication of the gear sets and bearings on the Hulett unloader, bridge, belt ore loader and unloader mechanism, etc.? Do you find it necessary to make seasonal changes, and if so, what practices do you have to handle same?

In emptying an ore boat with the Hulett unloader, what method do you have for taking care of the final clean-up in the location where the Hulett bucket cannot cover? Although you did mention that iron ore and coal was handled by boat at Lackawanna by virtue of your access to the lake—what means of transportation and handling is employed regarding your limestone requirements? How is the limestone then conveyed from that point of vantage to the furnace bins proper?

One figure illustrates a dual drive pulley arrangement and you also mentioned some problems associated with handling sticky ores. Have you found it necessary to provide scrapers to prevent the pick-up on the second pulley drive, or the belt itself?

In speaking of handling the sticky ores, have you had any experience with handling of raw concentrates in the same manner?

In looking at the various illustrations of the tremendous movement via belt conveyor, the question comes to mind as to how you control the safety features at transfer or dumping points, in other words, when one conveyor section is in operation, and another is down for some reason or other? How do you prevent spill at that point of transfer? Are you protected in the event that a mechanical failure should take place, say with a coupling located between the belt drive gear set and the motor and/or between belt drive gear set and the pulley? What method have you employed to cover such contingencies?

A. H. Andrews: One question asked about the reversible belt No. 2 at the Lackawanna ore handling system. The length is roughly 1700 ft, center to center. I think that the main reason they had no trouble with training that belt is that there was very careful installation to begin with, and careful breaking in of the belt itself, to make sure that it was running right. Of course, there are various kinds of train idlers at various intervals which no doubt help to keep the belt running in first-rate order, but the initial break-in of the belt is the important part at that point. They have had no trouble at all in that respect.

Then another part of the question had to do with the take-up. That belt is in a gallery which runs over several railroad tracks and the take-up is near the head end of the system, and thus we had none of the troubles that might be associated with a belt close to the ground. The single take-up is located between the two drives.

The next question had to do with the difference between sticky and dry ore and the trouble that might be expected in changing from one type of ore to the other by blockages in the various chutes, and so forth.

I think probably you will find it true that if you design or set up for the worst material—that is, the sticky material—you will find that you have no trouble with the dry ore, the granular or lumpy ore.

At one point in the paper I mentioned the fact that we installed a beam across some of the chutes. That beam is parallel to the axis of the head pulley, so that the beam split the flow of ore in that chute in two directions and more or less ricocheted it off the two sides of the chute. If it happened to be a sticky ore, it would build up to a certain point on that beam—it might build up 2 or 2½ ft, but finally it would fall one way or the other, at the same time splitting the main flow of the ore into two directions.

Then there was a question on mobile equipment used to handle coal concerning the fact that we had changed to that at Lackawanna. I am afraid I did not make it clear that at Johnstown bridges are used on handling ore, and I am rather inclined to think that using what we usually think of as earth-moving equipment on ore would be a rather tough job. The ore is just too heavy to handle with self-loading mobile equipment. As to comparative cost, we do not have figures available. Mobile equipment has been in use only a comparatively short time at Lackawanna for handling coal.

The factor that will point you straight on the cost question is the capacity and speed of the usual coal bridge. At Sparrows Point the largest coal bridge handles about 19 or 20 tons at a bite and while it is a fairly fast bridge, it cannot keep up with a system that would combine belts with mobile equipment. If you have a belt that will handle as much as 2000 tons of coal per hour, with a mobile handling equipment to supplement that and spread the coal into storage, such a system will beat the bridge in capacity. Assuming that your maintenance of the mobile equipment is what it should be, the cost of handling coal by mobile equipment is lower, based on experience of power plants who have used mobile equipment for many years.

The question as to the Steelton rotary coal bridge and why it was designed as it was is a little beyond me. Forty-five years ago the consumption of coal was nothing compared to what it is today, and it was probably thought that the capacity of that bridge in the small area it covers was entirely adequate to do the job.

Mr. Schaake wanted to know how we got ore back from the lower to the higher belt. Of course, it is a matter of an inclined transfer belt. The lower belt when reversed will discharge onto the tail end of this transfer belt which goes up the incline to the point where it is above the high belt. A short transfer belt completes the movement to the high belt.

Another question was the difference between fines and lumps and the effect on the belt. If I interpret the question correctly, Mr. Schaake would like to know if there are any special conditions that have to be set up for handling fines as compared to the handling of lumps, and so forth. Actually, there was as far as I know, no special consideration of that problem. There certainly has been no trouble. In other words, your fines could be handled up an incline; the lumps could, also. You have, of course, the standard limitations on the incline, something about 16 to 18 degrees is about the maximum you would like to go. And of course when you get into the matter of trying to handle pellets, on an inclined conveyor belt, it is like a bagful of marbles, and you are going to have special problems to study out there. A belt speed of 500 fpm makes it difficult to load a belt on an incline, but once the material has settled, 18 degree inclines are all right.

Mr. Potter of Lukens wanted to know how we unfreeze cars. I assume he was thinking back to the weather I described at Lackawanna. It is cold country. We have car sheds up there that will handle 60 cars on four tracks. Those thawing sheds have been adequate to handle the frozen coal and keep fairly well ahead of the car dumper in cold weather. Of course, frozen lumps will cause some delay, but without the sheds, operations would practically halt.

H. W. Potter: Are these steam sheds?

A. H. Andrews: No, they are sheds with oil burners which heat air. The hot air is distributed by a duct system between the tracks.

Mr. Spitz inquired about the weighing of ore. There is no demand for weighing of ore at Lackawanna. However at Sparrows Point with foreign ores coming in, we have government requirements on weighing, etc. The ore unloading bridges are equipped with larry cars and weighing equipment, which handle that job. Occasionally, due to press of several ships coming in at one time, you must unload with unloaders in addition to the bridges. Then we do occasionally have to weigh with

the track scale, because unloaders are not scale equipped.

Mr. Pritchard inquired about the matter of whether at Lackawanna seasonal changes had to be made in the lubrication of idlers, the bearings, etc. That system has gone through one and a half winters, so far, and after some corrections were made on the original installation, as far as the type of grease was concerned, there have been no changes in lubrication.

Another question was what method was used in the final clean-up for boats at Lackawanna. They use a small bulldozer with rubber cleats in the hold of the ship along with some manual shoveling to clean out the hold. It is not the usual slushing operation, with the cable drag.

Another question, in connection with the Huletts was the matter of limestone. Limestone can be discharged directly from the Huletts into the ore field via the tail belt extending off the back of the Huletts. The Huletts can either deposit ore or limestone into that ore field by way of these tail belts or they can put ore, limestone or coal onto the new conveyor system which goes out to the new ore field.

There was the matter of sticky ore on the secondary pulley of dual drives. That was one of the things no doubt that gave the designers at Steelton a problem. However, there does not seem to be anything too serious about that now because belt cleaners and "rubber tire" return idlers keep the belt fairly clean. There is no great trouble about that dual drive. The secondary pulleys do not get too badly built up with ore.

Member: Do you use any scrapers?

A. H. Andrews: We do use scrapers. We have tried several kinds and presently are getting ready to try another kind. So that is an indication that there are some deficiencies and in order to cut down the amount of labor used in cleaning up around transfer points, we are trying to get a better belt-cleaning device.

And then, finally, there was a question as to safety in the matter of one part of the system running while the subsequent part or the part of the system just ahead of that, was stopped. A very satisfactory manner of interlocking controls has been installed as part of the original system, and it is working very well. The final belt on the system starts first, and you gradually work back until you get to the beginning. When the system stops, the first belt stops before the second. It is a matter of interlocking controls that prevents the dangers you mentioned.

SAFETY PRECAUTIONS IN BLOWING IN A BLAST FURNACE*

▲ THE following is a tabulation of preparations and precautions to be observed in blowing-in a blast furnace to which alterations and additions should be made according to local conditions and practices.

1. Notify all blast furnace division employees, along with related service, maintenance, and plant protection departments, including the railroad if it is not under plant jurisdiction, that the furnace is to be blown in and warn them of the attendant hazards involved. All plant and blast furnace personnel not involved in the blow-in should be barred from the furnace area, and guards posted at roadways and entrances to enforce this restriction.

2. In order that the number of men exposed be kept at a minimum during the danger period, all supplies that will be required for the first few days should be brought in before the furnace is started.

3. As important as supplies is the condition of mechanical equipment and so that maintenance requirements may also be minimized equipment. Particular attention should be paid to cooling water on furnace and stoves, as this item presents a double-barreled hazard.

4. Non-functioning of operating and auxiliary equipment may cause confusion and add to the inherent and extraordinary dangers of the blowing-in time. Some items to be checked are: signal system between blowing engines and furnace, oxygen and high pressure air lines, blow down all steam lines on furnace and dustcatcher, and pack slide valves on dustcatcher and water seals.

5. Because the ubiquitous gas seepage presents so many unusual problems to personnel in the first two days of the life of the furnace, an intensive educational and safety observance campaign must be instituted.

a. Rope off area around the furnace to be blown in and post "Danger—Gas" signs.

b. Review with employees safety rules for the specific area in which they are working and the specific instructions for the job they are doing.

c. Hold formal safety meetings with crews.

d. Conduct a gas rescue drill with workers on each shift prior to blow-in.

e. Supervisors and "safety man" check gas helmets and resuscitators at the start of each turn.

f. Have a CO testing device and a component operator available at all times.

g. All buildings, including the stockhouse in the vicinity of the furnace, are possible danger areas and no one must be permitted in them alone.

h. All crewmen must remain on the windward side of the furnace as much as possible.

i. All work such as "claying up" or sanding iron and slag runners should be finished before blast is put on furnace or postponed until "gassing" has diminished.

j. Where available, use natural or coke oven gas to dry out and heat up runners prior to first flush and cast.

k. Provide gas alarms in confined areas or buildings close to the furnace.

l. After blast has been put on furnace, designate a crew member to light bosh gas and to keep it lighted with a torch.

m. Men checking water on furnaces where such work is done above bustle pipe must wear gas masks and be accompanied by observers stationed below. This task must be performed by men working in pairs.

n. Gas helmets must be worn by persons working in areas shown to be gaseous by CO indicator.

o. The gas blowing out of tapping hole pipe must obviously be kept lighted until hole is stopped.

*Abstracted from paper by James M. Stapleton, Assistant to Vice President-Iron Production, United States Steel Corp., presented at Philadelphia Regional Technical Meeting of American Iron and Steel Institute, November 16, 1955.

COKE AND BY-PRODUCTS IN 1954

By I. E. MADSEN

. . . . data and material in this report are based on information or quoted from Mineral Market Reports M.M.S. No. 2413, July 1955, and M.M.S. No. 2446, November 23, 1955, issued by the Bureau of Mines, United States Dept. of the Interior . . . .

▲ PRODUCTION of oven and beehive coke, excluding breeze, in 1954 as reported to the Bureau of Mines, United States Department of the Interior, dropped 24 per cent from 1953. The decline in coke production, which started in the later months of 1953, continued during the first half of 1954 and reached a low point in August. In September, oven-coke output, following the upturn in pig iron and steel production, started to climb and increased in each succeeding month of 1954. Oven-coke plants owned and operated by iron and steel companies, classified by the Bureau of Mines as furnace plants, maintained a higher operating rate for the year than did other oven-coke (merchant) plants. Rate of production for the furnace plants averaged 77 per cent of capacity whereas the merchant plants operated at 61 per cent. The average for all oven-coke plants was 75 per cent, or 18 points below the 1953 figure.

Beehive-coke oven operations did not follow the upturn in industrial activity in the later months of 1954 and consequently output of beehive coke was the lowest on record. Practically all of the beehive-coke plants in the famous Connellsville district of Pennsylvania were idle during the entire year. The principal factors for the closing of beehive ovens were the substantial decrease in requirements of blast-furnace coke and the expansion of carbonizing capacity of slot-type coke ovens by the iron and steel companies. Reduced requirements of blast-furnace coke were the result of: (1) the low operating rates of blast furnaces and (2) a marked improvement in fuel efficiency of the furnaces. In 1954, blast furnaces producing pig iron used 67 lb less coke per ton of pig iron produced than in 1953. While this savings appears small, it amounted to more than 1,900,000 tons of coke when based on the 1954 pig-iron production.

The annual coke capacity of slot-type coke ovens increased 337,600 tons during 1954 and totaled 78,595,600 tons at the end of the year. The 1954 gain in capacity was not as large as anticipated because the decline in demand for coke caused the permanent retirement of six batteries of coke ovens at merchant plants earlier than had been planned by the owners, and to a slackening in construction of new ovens by iron and steel companies. Annual coke capacity of slot-type ovens in the iron and steel industry increased 1,700,000 tons but this gain was nearly offset by the decline of 1,400,000 tons at merchant plants.

Although the coke industry experienced a slight decline in the delivered costs of coal, labor costs continued to rise. The average value of coal at both oven and beehive plants was $8.97 compared to $9.03 for 1953. These figures are not strictly comparable as the value in 1953 was influenced to a greater extent by the lower value for coal charged into beehive ovens, which represented seven per cent of the total quantity carbonized. In 1954, coal carbonized by beehive ovens amounted to only one per cent of the total. The reported value of coal at beehive ovens was actually $0.08 per ton higher but this was more than offset by the decline of $0.24 per ton for the coal delivered to oven-coke plants.

Labor costs increased slightly according to data published by the Bureau of Labor Statistics. The average weekly and hourly earnings of production workers for "coke and other petroleum and coal products" were $80.73 and $1.95, respectively, compared with $78.81 and $1.89 in 1953. The average hourly earnings increased $0.06 per hour or $1.92 per week based on 41.4 hours for the average time worked in 1954. According to the annual survey on employment conducted by the Bureau of Mines, employment declined in the coke industry, particularly at beehive plants. The average number of men working at beehive plants dropped to 1203 in 1954 from 2429 reported in 1953, and manhours worked dropped to 576,931 from 3,580,299 in 1953. For slot-type ovens, the average number of men working dropped from 21,011 employed in 1953 to 18,144 and manhours worked fell from 61,096,328 to 52,393,761 in 1954. These data relate to all workers in the coke industry subject to work hazards and include workers in construction, development, maintenance, and repair, as well as supervisory and technical personnel in the plants, but not including office workers.

Production of coal chemicals depends largely on coke-oven operations since they are made by the processing

TABLE I

Statistical Trends of the Coke Industry in the United States

	1937	1951	1952	1953	1954
Production:					
Oven coke, net tons	49,210,748	71,987,172	63,850,115	73,593,528	59,061,442
Beehive coke, net tons	3,164,721	7,343,530	4,403,994	5,243,329	601,054
Total, net tons	52,375,469	79,330,702	68,254,109	78,836,857	59,662,496
Per cent oven coke	94.0	90.7	93.5	93.4	99.1
Stocks of coke, end of year, net tons	2,595,287	1,482,972	1,901,657	2,679,708	2,948,840
Exports, all coke, net tons	526,683	1,026,730	792,072	520,252	384,377
Imports, all coke, net tons	286,364	161,639	312,519	157,318	115,781
Indicated consumption, all coke, net tons	51,271,929	78,093,353	67,355,871	77,695,872	59,124,768
Disposal, all coke sold or used:					
Furnace coke, net tons	36,751,969	67,440,987	58,182,747	69,728,500	51,973,401
Foundry coke, net tons	2,038,822	3,805,686	3,102,446	3,040,971	2,568,561
Other industrial coke (including producer and water gas), net tons	4,597,894	5,603,262	4,648,077	4,006,560	3,472,132
Domestic coke, net tons	8,107,518	2,087,934	1,932,369	1,467,962	1,266,722
Carbonizing equipment:					
By-product ovens in existence, end of year	12,718	15,319	15,608	15,989	15,891
Beehive ovens in existence, end of year	12,194	20,458	17,551	15,092	12,216
By-product ovens under construction, end of year	259	398	1,075	779	490
Cost of coal charged, oven-coke plants average per ton	$3.74	$8.94	$9.23	$9.24	$9.00
Prices of coke:					
Average realization on oven coke sold (merchant sales):					
Furnace coke	$4.34	$15.64	$16.29	$16.37	$13.83
Foundry coke	$8.47	$22.19	$22.49	$23.87	$23.40
Other industrial coke (including water gas)	$6.08	$14.44	$14.10	$14.00	$12.70
Domestic coke	$6.53	$14.45	$14.75	$15.25	$14.83
Yield of by-products per ton of coal charged:					
Tar, gal	8.67	7.78	7.74	7.90	8.46
Ammonium sulphate or equivalent, lb	21.84	19.82	19.92	20.09	21.09
Crude light oil, gal	2.86	2.83	2.79	2.90	2.98
Surplus gas sold or used, M cu ft	6.66	6.38	6.35	6.41	6.68
Average gross receipts for by-products, per ton of coke produced:					
Crude tar sold and used (exclusive of amount used by producers for own use in refining and topping and exclusive of tar derivatives)	$0.502	$0.757	$0.774	$0.806	$0.923
Ammonia and its compounds	$0.326	$0.501	$0.556	$0.536	$0.605
Crude light oil and its derivatives (including naphthalene)	$0.435	$1.179	$1.149	$1.247	$1.249
Surplus gas sold or used	$1.483	$1.921	$1.921	$2.005	$2.178
Total coal-chemical materials (including breeze)	$2.974	$4.927	$4.98	$5.19	$5.57

of the ammonia, tar, and light oil recovered from the gas stream. The decline in coke-oven operations reduced output of the coal-chemical materials, and ammonia production (NH_3 equivalent to all forms) fell 15 per cent; crude tar, 14 per cent; and crude light oil, 17 per cent. Production of the various derivatives of these basic materials showed wider fluctuation. The ammonia products, sulphate and liquor, decreased 13 and 35 per cent, respectively. The principal light-oil derivatives: benzene, toluene, and solvent naphtha fell 20, 7, and 27 per cent, respectively, while xylene output increased slightly. The main tar derivatives; creosote oil, crude chemical oil, phenol, and pitch dropped 29, 7, 9, and 15 per cent, respectively. Although crude naphthalene production declined 11 per cent in 1954, new facilities completed in the latter part of the year prevented a larger decrease. These facilities enabled the coke-producing companies to produce a higher quality naphthalene pure enough to use in the manufacture of certain synthetic organic chemical intermediates without further processing and upgrading. Prior to 1954, more than 50 per cent of the crude naphthalene produced at oven-coke plants was not suitable for the manufacture of intermediates and had to be upgraded by chemical companies. The change in quality of naphthalene made at coke plants was quite noticeable in 1954. Less than one-fourth of the total produced had a solidification point of less than 74 C compared with 50 per cent in 1953. It was apparent, therefore, that more than three-fourths of the 1954 output of coke-oven naphthalene was used by the chemical industry without any further refinement.

Markets for most of the coal chemicals held up fairly well in 1954 and at the end of the year there was little change in stocks at producing plants from those of the previous year. Prices on most of the coal chemicals remained about the same as in 1953 although prices were reduced on several commodities. Ammonium sulphate was cut between $2 and $3 per ton by coke-oven operators around the middle of the year and is reflected by the average value reported to the Bureau of Mines of $0.021 per lb compared with $0.022 in 1953. In the last quarter of 1954, some resistance was shown by benzene consumers to the prevailing prices and a $0.04 per gallon reduction occurred in the first week of January 1955. This, however, did not affect the 1954 average value shown in this review for the specification grades of benzene. Pyridine prices, which started to decline in 1953, fell farther in 1954 and the refined 2 degree grade averaged $0.879 per lb. However, the year as a whole was a fairly good year, and the total value of coal-chemical materials sold amounted to $292,243,755 or only 16 per cent lower than the record figure of 1953.

Additional statistics are covered under their respective topics in the following sections and in Tables I, II, III and IV.

TABLE II

Salient Statistics of the Coke Industry in the United States in 1954

		By-product	Beehive ovens	Total
Coke produced — At merchant plants	net tons	7,362,967	(1)	
At furnace plants	net tons	51,698,475	(1)	
Total	net tons	59,061,442	601,054	59,662,496
Screenings or breeze produced	net tons	3,930,553	27,523	3,958,076
Coal charged into ovens	net tons	84,639,973	979,646	85,619,619
Average value of coal per ton		$9.00	$6.44	$8.97
Average yield in per cent of total coal charged —				
Coke		69.78	61.35	69.68
Breeze (at plants actually recovering)		4.65	6.72	4.66
Ovens — In existence January 1		15,989	15,092	31,081
In existence December 31		15,891	12,216	28,107
Dismantled during year		866	2,972 (3)	3,838
In course of construction December 31		490	23	513
Annual coke capacity December 31	net tons	78,595,600	8,077,800	86,673,400
Coke used by producer — In blast furnaces	net tons	50,056,776	204,878	50,261,654
In foundries	net tons	240,107	—	240,107
To make producer gas	net tons	342,148	—	342,148
To make water gas	net tons	1,028,646	—	1,028,646
For other purposes	net tons	538,146	121	538,267
Coke sold — (Commercial sales)				
For blast furnace use	net tons	1,597,560	114,187	1,711,747
For foundry use	net tons	2,296,200	32,254	2,328,454
For manufacture of water gas	net tons	63,145	57	63,202
For other industrial use	net tons	1,248,836	251,033	1,499,869
For domestic use	net tons	1,263,414	3,308	1,266,722
Disposal of screenings or breeze —				
Used by producer — For steam	net tons	2,480,581	—	2,480,581
To make producer or water gas	net tons	33,716	—	33,716
For other purposes	net tons	976,849	—	976,849
Sold	net tons	841,845	56,734	898,579
Average receipts per ton sold (merchant sales)				
Furnace coke		$13.83	$14.38	$13.87
Foundry coke		$23.40	$15.35	$23.29
Water-gas coke		$16.81	$12.65	$16.80
Other industrial coke		$12.49	$12.81	$12.54
Domestic coke		$14.83	$12.79	$14.83
Screenings or breeze		$5.44	$5.51	$5.45
Stocks on December 31, 1952:				
Furnace coke	net tons	2,063,468	2,011	2,065,479
Foundry coke	net tons	140,556	808	141,364
Domestic and other coke	net tons	737,547	4,450	741,997
Screenings or breeze	net tons	663,645	440	664,085
By-products produced — Tar	gal	715,840,473	—	715,840,473
Ammonium sulphate or equivalent	lb	1,774,464,664	—	1,774,464,664
Gas	M cu ft	869,874,515	—	869,874,515
Burned in coking process	per cent	34.31	—	34.31
Surplus sold or used	per cent	64.19	—	64.19
Wasted	per cent	1.50	—	1.50
Crude light oil	gal	246,018,627	—	246,018,627
Yield of by-products per ton of coal —				
Tar	gal	8.46	—	8.46
Ammonium sulphate or equivalent	lb	21.09	—	21.09
Gas	M cu ft	10.28	—	10.28
Crude light oil	gal	2.98	—	2.98
Coal used per ton of coke	tons	1.43	1.63	1.43
Value of coke at ovens		$940,769,073	$8,511,488	$949,280,561
Value of screenings or breeze		$19,964,416	$174,217	$20,138,633
Value of by-products sold — Tar sold and used by producer		$54,600,638	—	$54,600,638
Ammonia (sulphate and liquor)		$35,711,119	—	$35,711,119
Gas (surplus)		$128,565,914	—	$128,565,914
Crude light oil and derivatives		$69,362,454	—	$69,362,454
Other coal-chemical materials (2)		$20,117,086	—	$20,117,086
Total value of coke and breeze produced and coal-chemical materials sold and tar used by producer		$1,269,090,700	$8,685,705	$1,277,776,405

(1) Not separately recorded.

(2) Naphthalene, tar derivatives, and miscellaneous coal-chemical materials.

(3) Includes idle ovens, not expected to go back into production.

PRODUCTION OF COKE

Daily production of by-product coke averaged 161,700 tons in 1954 compared with 201,600 tons per day in 1953. Daily production from beehive ovens averaged 1650 tons per day compared with 14,400 tons in 1953. The drop in production reflected primarily the cutbacks in steel production and to a lesser degree, cutbacks in other industrial operations. The leading states in the order of their importance in the production of by-product coke are Pennsylvania, Ohio, Indiana, Alabama and West Virginia. West Virginia was only slightly ahead of New York and Maryland, and had displaced New York who was in the fifth place position in 1953. The first five states produced about 69.4 per

TABLE III

Summary of Coke-Oven Operations in the United States in 1954, by States

State	Oven coke						
	In existence December 31 (1)		Coal carbonized (net tons)	Yield of coke from coal (per cent)	Coke produced (net tons)	Value of coke at ovens	
	Plants	Ovens				Total	Per ton
Alabama	7	1,389	7,265,403	72.97	5,301,550	$88,993,489	$16.79
California	1	225	1,068,156	58.75	627,577	(2)	(2)
Colorado	1	257	976,495	67.82	662,282	(2)	(2)
Illinois	8	711	3,209,485	70.05	2,248,206	38,969,746	17.33
Indiana	5	2,003	11,570,447	70.87	8,200,262	144,961,650	17.68
Maryland	1	687	4,252,947	72.38	3,078,371	(2)	(2)
Massachusetts	1	108	755,456	68.35	516,344	(2)	(2)
Michigan	4	691	3,129,883	73.77	2,308,924	41,287,925	17.88
Minnesota	3	241	1,134,362	70.86	803,860	17,952,483	22.33
New Jersey	2	341	1,307,844	71.09	929,768	(2)	(2)
New York	4	862	5,178,791	69.10	3,578,703	52,685,854	14.72
Ohio	16	2,533	11,877,465	69.28	8,228,873	126,685,567	15.40
Pennsylvania	14	4,017	23,013,594	67.64	15,566,002	232,195,163	14.92
Tennessee	1	44	194,714	79.19	154,194	(2)	(2)
Texas	2	140	980,102	71.37	699,536	(2)	(2)
Utah	2	308	1,538,594	64.85	997,749	(2)	(2)
West Virginia	5	772	5,183,406	71.55	3,708,905	43,609,417	11.76
Connecticut, Kentucky, Missouri and Wisconsin	4	562	2,002,829	72.41	1,450,336	25,220,963	17.39
Undistributed	.....	.....	.....	.....	.....	128,206,816	16.72
Total 1954	81	15,891	84,639,973	69.78	59,061,442	940,769,073	15.93
At merchant plants	23	2,458	10,277,302	71.64	7,362,967	122,679,136	16.66
At furnace plants	58	13,433	74,362,671	69.52	51,698,475	818,089,937	15.82
Total 1953	82	15,989	104,922,927	70.14	73,593,528	1,080,304,156	14.68

State	Beehive coke						Total	
	Ovens in existence Dec. 31	Coal carbonized (net tons)	Yield of coke from coal (per cent)	Coke produced (net tons)	Value of coke at ovens		Coke produced (net tons)	Value of coke at ovens
					Total	Per ton		
Alabama	.....	.....	.....	.....	.....	.....	5,301,550	$88,993,489
California	.....	.....	.....	.....	.....	.....	627,577	(2)
Colorado	.....	.....	.....	.....	.....	.....	662,282	(2)
Illinois	.....	.....	.....	.....	.....	.....	2,248,206	38,969,746
Indiana	.....	.....	.....	.....	.....	.....	8,200,262	144,961,650
Maryland	.....	.....	.....	.....	.....	.....	3,078,371	(2)
Massachusetts	.....	.....	.....	.....	.....	.....	516,344	(2)
Michigan	.....	.....	.....	.....	.....	.....	2,308,924	41,287,925
Minnesota	.....	.....	.....	.....	.....	.....	803,860	17,952,483
New Jersey	.....	.....	.....	.....	.....	.....	929,768	(2)
New York	.....	.....	.....	.....	.....	.....	3,578,703	52,685,854
Ohio	.....	.....	.....	.....	.....	.....	8,228,873	126,685,567
Pennsylvania	10,407	668,179	64.66	432,061	$5,884,403	$13.62	15,998,063	238,079,566
Tennessee	.....	.....	.....	.....	.....	.....	154,194	(2)
Texas	.....	.....	.....	.....	.....	.....	699,536	(2)
Utah	297	106,976	54.74	58,558	(2)	(2)	1,056,307	(2)
Virginia	482	140,195	51.42	72,092	1,032,462	14.32	72,092	1,032,462
West Virginia	835	64,296	59.64	38,343	(2)	(2)	3,747,248	(2)
Connecticut, Kentucky, Missouri and Wisconsin	195	.....	.....	.....	.....	.....	1,450,336	25,220,963
Undistributed	.....	.....	.....	.....	1,594,623	16.46	.....	173,410,856
Total 1954	12,216	979,646	61.35	601,054	8,511,488	14.16	59,662,496	949,280,561
Total 1953	15,092	8,226,097	63.74	5,243,329	76,257,848	14.54	78,836,857	1,156,562,004

(1) Excludes plants retired permanently during year.
(2) Included with "Undistributed" to avoid disclosure of individual company figures.

cent of the national production of oven coke compared with 63.7 per cent for the first five states in 1953. The leading producer of beehive coke in 1954 was Pennsylvania with 432,061 tons, or 71.9 per cent of the total. In 1953, Pennsylvania produced 4,635,313 tons of beehive coke. These figures illustrate the difficulty which beehive coke has in meeting the competition of the by-product ovens when demand for coke is reduced. Pennsylvania was the leading coke producer with 15,998,063 tons for 26.8 per cent of the total. This is a slight decrease from the 29.6 per cent share which Pennsylvania had in 1953.

TABLE IV

Coal-Chemical Materials Produced at Coke-Oven Installations in the United States in 1954 (1)

(Exclusive of Breeze)

Product		Produced	Sold			On hand December 31
			Quantity	Value		
				Total	Average	
Tar, crude	gal	715,840,473	(2)355,878,669	$38,487,182	$0.108	30,823,791
Tar derivatives:						
Creosote oil:						
Distillate as such (100 per cent creosote)	gal	19,587,965	18,959,350	3,609,856	0.190	1,978,536
In coal-tar solution (100 per cent solution basis)	gal	6,881,563	6,688,549	1,281,758	0.192	191,187
Crude chemical oil	gal	23,087,245	23,522,083	4,936,176	0.210	1,054,528
Phenol	lb	8,740,568	6,689,928	851,893	0.127	294,766
Pitch of tar:						
Soft (3)	net tons	557,573	17,808	496,444	27.878	2,900
Medium (4)	net tons	15,999	15,512	521,445	33.616	179
Hard (5)	net tons	177,509	9,527	238,710	25.056	5,722
Other tar derivatives (6)		.....	.....	1,886,598	.....	.....
Ammonia:						
Sulphate	lb	1,645,636,400	1,638,967,393	34,644,877	0.021	312,592,422
Liquor (NH_3 content) (7)	lb	32,207,066	19,596,259	1,066,242	0.054	3,069,361
Total	lb	.....	.....	35,711,119	.....	.....
Sulphate equivalent of all forms	lb	1,744,464,664	1,717,352,429	.....	.....	.....
NH_3 equivalent of all forms	lb	443,616,166	429,338,107	.....	.....	.....
Gas, M cu ft:						
Used under boilers, etc.		(8)869,874,515	45,961,044	7,735,574	0.168	.....
Used in steel or allied plants			408,635,974	83,931,014	0.205	.....
Distributed through city mains			76,732,276	31,352,649	0.409	.....
Sold for industrial use			27,013,853	5,546,677	0.205	.....
Total		(8)869,874,515	558,343,147	128,565,914	0.230	.....
Crude light oil	gal	(9)246,018,627	14,647,521	3,495,456	0.239	4,081,771
Light-oil derivatives:						
Benzene:						
Specification grades (1 degree, 2 degree and 90 per cent)	gal	138,260,660	130,906,579	50,625,864	0.387	10,898,036
Other industrial grades	gal	1,177,126	950,845	331,847	0.349	82,864
Motor grade	gal	3,327,096	3,254,807	571,678	0.176	86,589
Toluene (all grades)	gal	33,383,028	30,547,931	9,663,976	0.316	3,033,222
Xylene (all grades)	gal	9,956,303	9,527,187	3,120,709	0.328	803,253
Solvent naphtha (crude and refined)	gal	4,582,782	4,559,895	1,197,206	0.263	323,509
Other light-oil products	gal	4,072,737	2,705,032	355,718	0.132	220,141
Total	gal	194,759,732	182,452,276	65,866,998	0.361	15,447,614
Intermediate light oil	gal	2,907,059	2,983,978	496,874	0.167	139,493
Naphthalene (crude):						
Solidifying at less than 74 C	lb	22,857,876	24,675,886	642,887	0.026	1,802,484
At 74 and less than 76 C	lb	9,235,471	2,580,670	93,397	0.036	418,041
At 76 and less than 79 C	lb	67,965,684	70,045,315	3,632,978	0.052	1,017,661
Pyridine:						
Crude bases (dry basis)	gal	232,045	280,515	393,313	1.403	159,035
Refined (2 C)	lb	580,669	620,671	545,851	0.879	287,667
Picolines	lb	208,545	190,651	77,071	0.404	49,292
Sodium phenolate	gal	3,324,777	2,616,773	306,909	0.117	880,109
Sulphur	lb	6,694,940	7,786,410	104,926	0.013	503,490
Value of all coal-chemical materials sold		.....	.....	$292,243,755	.....	.....

(1) Includes products of tar distillation conducted by coke-oven operators under same corporate name.

(2) Includes 28,059,083 gal sold to affiliated companies for refining.

(3) Water-softening point, less than 110 F.

(4) Water-softening point, 110 to 160 F.

(5) Water-softening point, over 160 F.

(6) Cresols, cresylic acid, pitch coke, resin oil, road tar, tar paint, and topped or refined tar.

(7) Includes small amount of ammonium thiocyanate.

(8) Includes gas used for heating ovens and gas wasted.

(9) 233,983,106 gal refined by coke-oven operators to make derived products shown.

NUMBER AND CAPACITY OF OVENS

At the end of 1954, there were a total of 15,891 by-product ovens. This is a slight decrease in the number of ovens from the 15,989 in existence in 1953, but, on the other hand, these ovens have a slightly higher capacity being rated at 78,595,600 tons at the end of 1954 compared with 78,258,000 tons at the end of 1953. The year 1954 saw a total of 768 ovens with an annual capacity of 4,034,300 tons completed. Some 866 ovens were abandoned, and at the end of the year 490 ovens with an annual capacity of 2,279,000 tons were under construction. The largest number of new ovens were located in Pennsylvania where 192 were built with an annual capacity of 864,900 tons. Second was Indiana with 154 ovens rated at 687,600 tons, and Ohio was third with 121 ovens rated at 658,600 tons. Pennsylvania had the largest number of ovens abandoned with 252, and Illinois was next, abandoning 223 units. At the end of 1954, the total number of beehive ovens was 12,216 compared with 15,092 at the end of 1953. These had an annual capacity of 8,077,800 tons compared with 10,072,700 tons the previous year. This continues the steady drop which has been under way for several years. Of the ovens in existence, 10,736 were in operating condition, and these had an annual capacity of 7,204,800 tons. A total of 33 ovens were rebuilt in 1954 compared with 105 in 1953. A total of 2972 were abandoned in 1954 compared with 2564 abandoned in 1953. These totals include the units which are idle and not expected to resume production. There were 23 beehive units under construction at the end of the year, all in Pennsylvania. In addition 33 units, rebuilt during the year, were in Pennsylvania. Pennsylvania had the largest number of ovens in operating condition with a total of 9410 with an annual capacity of 6,582,400 tons for 91.4 per cent of all the beehive capacity in operating condition.

The reduction in steel demand was reflected in oven construction, and the pressure to build new units was relaxed considerably during the year.

COAL CHARGED INTO COKE OVENS

In 1954 a total of 85,619,619 tons of coal were charged into coke ovens. This included a total of 84,639,973 tons valued at $761,516,255 which were charged into by-product ovens and 979,646 tons of coal valued at $6,304,656 charged into beehive ovens. Average value of coal for by-product ovens was $9 a ton, and that for the beehive ovens was $6.44 a ton. The figure for the coal charged into by-product ovens includes 229,373 tons of anthracite valued at $8.51 a ton. The cost of the coal needed to make one ton of by-product coke was $12.89 compared with $13.17 a ton in 1953. It took 1.43 tons of coal to make a ton of coke which is exactly the same as 1953. The cost of coal (1.63 tons) needed to make one ton of beehive coke in 1954 was $10.49 a ton compared with $9.97 a ton in 1953. It took more coal in 1954 as the 1953 figure was 1.57 tons of coal per ton of beehive coke. The leading states in the mining of coking coal for by-product ovens are in the order of their production, West Virginia, Pennsylvania, Kentucky and Alabama who produced 30,631,910; 29,715,970; 9,611,294 and 6,907,991 tons of coal of the 83,285,893 tons which were mined.

COKE USAGE AND DISTRIBUTION

In 1954, blast furnaces used a total of 51,973,401 tons or 87.3 per cent of the 59,662,496 tons produced. This is an appreciable reduction from the 69,728,500 tons of coke used in 1953. The drop in steel production was reflected directly in a drop in the demand for coke. Coke used per net ton of pig iron in 1954 dropped to 1763.3 lb compared with 1834.9 lb in 1953. This shows also more efficient blast furnace operation, and is the lowest figure since 1941 when the value was 1746 lb. Since the yield of coke from coal was 69.78 per cent, 2529.8 lb of coal were used per net ton of pig iron and ferroalloys. Total commercial sales of coke for blast furnace use was 1,711,747 tons. The volume of coke delivered to iron foundries was 2,568,565 tons and represented 4.3 per cent of the total coke produced during the year. Coke for producer gas and water gas continued to decline. The total use for this purpose in 1954 shows 1,433,996 tons or 2.4 per cent of total coke consumption. This percentage is slightly over last year, but the tonnage was only 75 per cent of the 1,900,000 tons used in 1953. The quantity of coke needed for other industrial usage dropped from 2,100,000 tons in 1953 to 1,499,869 tons in 1954. The market for residential heating coke also continued its drop with 1,266,722 tons being used in 1954 compared with about 1,500,000 tons in 1953.

As seen by the previous figures, the iron and steel industry used the bulk of the coke produced, and this industry also produces the bulk of the coke. Coke movement thus follows this industry. In general, the majority of the coke was used close to where it was produced, and this is particularly true for the larger plants. As an example, Pennsylvania which produced 15,998,063 tons of coke consumed 14,850,505 tons. Ohio was the second largest consumer with 10,232,549 tons but produced only 8,228,873 tons thus being a net importer of coke. Indiana used 6,450,165 tons of the 8,200,262 tons which it produced. In general, however, the coke movements represented by these latter two cases were usually within the Chicago and Pittsburgh steelmaking districts which are split by state lines.

Although coke was produced in only 21 of the 48 states, every state and the District of Columbia was a user of coke. However, such usage varied widely, and in some cases represented rather substantial movements of coke. Pennsylvania was the leader in coke consumption with 14,850,505 tons, Ohio was second with 10,232,549 tons, Indiana was third with 6,450,165 tons, Alabama was fourth with 4,575,727 tons and Illinois was fifth with 4,247,929 tons. Thus these first five states used 40,356,875 tons or 68.2 per cent of all the coke consumed.

STOCKS OF COKE AND COKING COAL

Total stocks of by-product coke at the end of 1954 of blast furnace coke was 2,063,468 tons, foundry coke stocks totaled 140,566 tons and domestic and other coke stocks totaled 737,547 tons for total stock of 2,941,571 tons compared with 2,679,708 tons at by-product plants at the end of 1953. Stocks at beehive

plants totaled 7269 tons, about one-half of the 13,222 tons at the end of 1953. Thus, total stocks at the end of the year were 2,948,840 tons. Stocks of coke breeze at by-product plants totaled 663,645 tons and at beehive plants totaled 440 tons. This is appreciably less than 858,001 tons on hand at the end of 1953. Coal stocks declined at the end of the year since in January, 14,885,244 tons were on hand, and this declined to 12,356,618 tons of bituminous coal at the end of the year. A low of 11,125,064 tons occurred in July. Anthracite stock at oven coke plants at the end of the year totaled 54,130 tons compared with 72,594 tons in January and a low of 37,234 tons in May.

GROSS VALUE AND YIELD OF BY-PRODUCTS

The total gross value of the by-products which were sold in 1953, exclusive of the value of the coke breeze produced, totaled $292,243,755 which is 16 per cent lower than the $346,519,393 sold in 1953. The gross value of the by-products was 30.8 per cent of the $949,280,561, the value of all the coke produced during the year. An average of $21.50 per ton of by-product coke produced was realized for the coke, coke breeze and coal chemical materials. This includes $15.93 for the coke and $5.57 for the breeze and coke chemical materials. Coal cost per ton of by-product coke was $12.89. Coal costs per ton of beehive coke was $10.49. In general, yields of the primary coke by-products was greater in 1954 than in 1953 reflecting the increased efficiency of the ovens. Compared with 1953, tar yield increased to 8.4 gal per ton of coal compared with 7.90; ammonium sulphate or equivalent increased to 21.09 from 20.09; crude light oil increased to 2.98 gal from 2.90 gal; and the surplus gas sold or used increased to 6.69 M cu ft from 6.41 M cu ft.

EFFECT ON NATURAL GAS

Marketed production of natural gas in the United States totaled 8,743,000,000,000 cu ft in 1954. The increase over 1953 was the smallest in any one year since 1946.

Natural gas was consumed in 43 states and the District of Columbia in 1954, Nevada receiving it for the first time. Consumption in the United States totaled 8,403,000,000,000 cu ft. Consumption increased by over 5 per cent in spite of the lower gain in marketed production as the result of large withdrawals from storage. The quantities used by various classes of consumers in 1954 and the percentage change compared with 1953 were as follows: residential, 1,894,000,000,000 cu ft, +12 per cent; commercial, 585,000,000,000 cu ft, +10 per cent; field, 1,457,000,000,000 cu ft, −1 per cent; petroleum refineries, 563,000,000,000 cu ft, +1 per cent; and other industrial, 3,909,000,000,000 cu ft, +5 per cent.

The average value of natural gas at the wellhead in 1954 was 10.1 cents per thousand cu ft, an increase of 0.9 cents per thousand cu ft over 1953. The total value of marketed production at the wellhead was $883,000,000.

The average value of natural gas at point of consumption in 1954 was 38.0 cents per thousand cu ft, 2.5 cents higher than in 1953.

The gross addition of natural gas to underground storage was 432,000,000,000 cu ft. Withdrawals from underground storage of 330,000,000,000 cu ft were 34 per cent larger than in 1953.

Interstate shipments and exports of natural gas increased 11 per cent in 1954 and constituted 53 per cent of marketed production.

The number of residential consumers increased by 1,100,000 to 25,300,000.

1956

AISE CONVENTION AND EXPOSITION

CLEVELAND, OHIO

SEPTEMBER 25, 26, 27, 28

By C. C. THOMAS, Steel Mill Engineering, General Electric Co., Schenectady, N. Y.

Electric Equipment for Reversing Hot Strip Mills

. . . . the reversing hot strip mill is an economical unit for the smaller operator, particularly if production involves a large variety of small tonnage orders . . . . units can furnish a wide range of product . . . . the reheat furnaces on the coilers provide heat to compensate for the slow speed operation . . . . units are still relatively new and practice is not yet definitely established . . . .

▲ UNTIL 1949 a reversing hot strip mill was indeed a rare type steel mill. In 1948 there were in operation in these United States 29 wide hot strip mills with either continuous or reversing roughers and continuous finishing trains. There was a grand total of one reversing hot strip mill located in Detroit at McLouth Steel's Livernoise plant. The 29 continuous or semi-continuous mills were turning out nearly 25,000,000 tons of hot strip per year while the lone reversing hot strip mill was probably producing around 100,000 tons of strip per year. Therefore it might be well to explain briefly what a reversing hot strip mill is — where it fits into the overall picture, some of its history and its expected future.

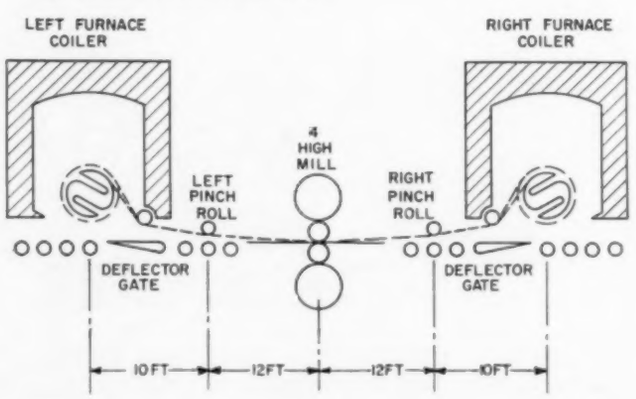
WHAT IS A REVERSING HOT STRIP MILL

A hot strip mill is generally thought of as a line of mill stands which starts either with an ingot or a reheated slab and produces hot strip. If the hot metal goes direct from the slab to strip without reversing direction for a second pass in any stand it is defined as a continuous hot strip mill. If, as is quite common, the roughing passes are made on reversing mill stands and the finishing passes are made in continuous stands, the complete mill is referred to as a semi-continuous hot strip mill. If the finishing passes are also taken on a reversing mill then the entire setup, consisting of both reversing rougher and reversing finisher, could logically be called a reversing hot strip mill. Both roughing passes and finishing passes could be made on one stand. However, the trend is to have one 2-high mill stand act as a reversing rougher and another 4-high mill stand act as a reversing finisher. This discussion will deal primarily with the reversing finishing mill with only brief comments on the overall picture to show how the roughing mill fits into this.

One big difference between reversing hot strip mills and the continuous mills is that most of the latter work from reheated slabs while most of the former work from the ingot heat. A typical reversing hot strip mill, then, would contain first a reversing slabbing mill complete with either attached or detached edger. This slabbing mill would rough down the ingot to about 1-in. material called strip plate in 35 passes or so depending on the size of ingot and the product to be rolled.

From the slabbing mill, the steel would go directly to the reversing single stand finishing mill. On either side of this mill stand — placed sufficiently above the table that the plate may pass freely underneath — are located coiling furnaces containing coiling reels. See Figure 1. The finishing mill will continue to pass the plate back and forth several times, or, until it has been reduced to about ½ in. in thickness. Then, on the next pass, a deflector gate will send the front end of the strip into one of the coiling furnaces. After most of the strip

Figure 1 — Typical reversing hot strip finishing mill elevation shows relations of mill, pinch rolls, deflector gates and furnace coilers.



has been wound on the coiling reel, the tail end passes entirely through the mill but stops before it has reached a set of pinch rolls (located between the mill and the furnace coiler on either side). The mill then reverses and the pinch roll pulls the hot strip out of the furnace coiler (which now acts as an uncoiler) into the mill. The deflector gate on the opposite side will then raise the strip into the other coiling furnace. This process is repeated for about five passes, and on the last pass the strip, instead of being coiled in the furnace, is run out on tables as on continuous hot strip mills and coiled in either an up or down coiler.

WHY IS THERE A NEED FOR SUCH A MILL?

Most of the hot strip produced today is rolled on continuous hot strip mills. These mills, if pushed to capacity, can and do roll fabulous tonnages in most cases. The producer who has the raw material to keep these mills operating at a high per cent of their capacity is obviously going to produce less expensive strip than a similar mill producing a lower tonnage. Therefore, an operator who needs a low tonnage mill is handicapped. Since some finishing trains have a theoretical capacity of as high as 500 tons per hour, or on the basis of an 8000-hr year — 4,000,000 tons per year, it is easy to see that if someone wants to produce only 250,000 tons of strip per year, he must find a smaller mill, or lose money. The idea of using a continuous mill for such small tonnages is of course out. The roughing stands and slabbing mill could be replaced by a reversing universal mill. The reheat furnaces could be cut down to match the lower tonnage, but the finishing train is a problem — to cut down the number of stands limits the range of products — to cut down the speed and therefore horsepower has definite limits because the metal

TABLE I

Existing Reversing Hot Strip Finishing Mills with Electric Equipment by U. S. Manufacturers

No.	Purchaser and location	Installed	Electrical manufacturer	Mill	Main motor				Furnace coiler		Pinch rolls	
				In.	Hp	Rpm	Fpm	Hp/in./100 fpm	Hp	Hp/in./100 fpm	Hp	Hp/in./100 fpm
1	Dominion Foundries & Steel (1) Hamilton, Ontario, Canada	1935	GE (5)	36—4-high	1750	70/125	400/700	12.2/7.0	100	0.397	100	0.397
2	McLouth Steel Corp. Detroit, Mich., U.S.A.	1936	GE (5)	20—2-high	2100	230/500	430/935	24.5/11.2	35	0.187	35	0.187
3	Crucible Steel Co. of America Midland, Pa., U.S.A.	1949	GE	66—4-high	5000	70/170	500/1200	15.2/6.3	300	0.379	150	0.190
4	Newport Steel Co. Newport, Ky., U.S.A.	1949 (6)	W	66—4-high	4000	100/200	655/1310	9.2/4.6	150	0.173	75	.....
5	McLouth Steel Corp. (2) Trenton, Mich., U.S.A.	1949	W	42—4-high	5000 (3)	125/312	820/2050	14.5/5.8	300	0.349	150	0.175
6	A. M. Byers Co. Ambridge, Pa., U.S.A.	1949	W	38—2-high	2500	70/150	570/1140	11.5/5.75	75	0.173	50	.....
7	A. R. B. E. D. Dudelange, Luxembourg	1950	GE	66—4-high	5000	70/170	500/1200	15.2/6.3	250	0.316	150	0.190
8	Com. Sid. Belgo Maniera Brazil, S.A.	1951	W	40—2-high	2000	80/160	608/1215	8.2/4.1	50	0.103	...	.....
9	Fagersta Bruks A.G. Fagersta, Sweden	1951	GE	29—4-high	2500	130/260	600/1200	14.4/7.2	100	0.287	...	.....
10	Altos Hornos de Mexico, S.A. Monclova, Coahula, Mexico	1952 (4)	W	48—4-high	3000	70/175	440/1100	14.2/5.67	150	0.284	75	0.450
11	Lone Star Steel Co. Dangerfield, Texas, U.S.A.	1953	W	72—4-high	7000 (3)	125/250	885/1770	11.0/5.5	600	0.470	150	0.118
12	Hojalata Y Lamina S.A Monterrey, N. L., Mexico	1953	GE	48—4-high	3000	70/175	440/1100	14.2/5.67	150	0.284	35	0.158
13	Dominion Foundries & Steel Hamilton, Ontario, Canada	1954	GE	60—4-high	6000 (3)	100/250	733/1830	13.6/5.5	550	0.550	150	0.138

NOTES:

(1) Shutdown on standby basis since installation of new mill.

(2) Sold to Spain, removed fall of 1954.

(3) Double armature main motor.

(4) Mill housing mechanically arranged to open to roll 72-in. plate or close to 48 in. to roll strip.

(5) Using existing (W) rotating equipment.

(6) New mill installed 1954.

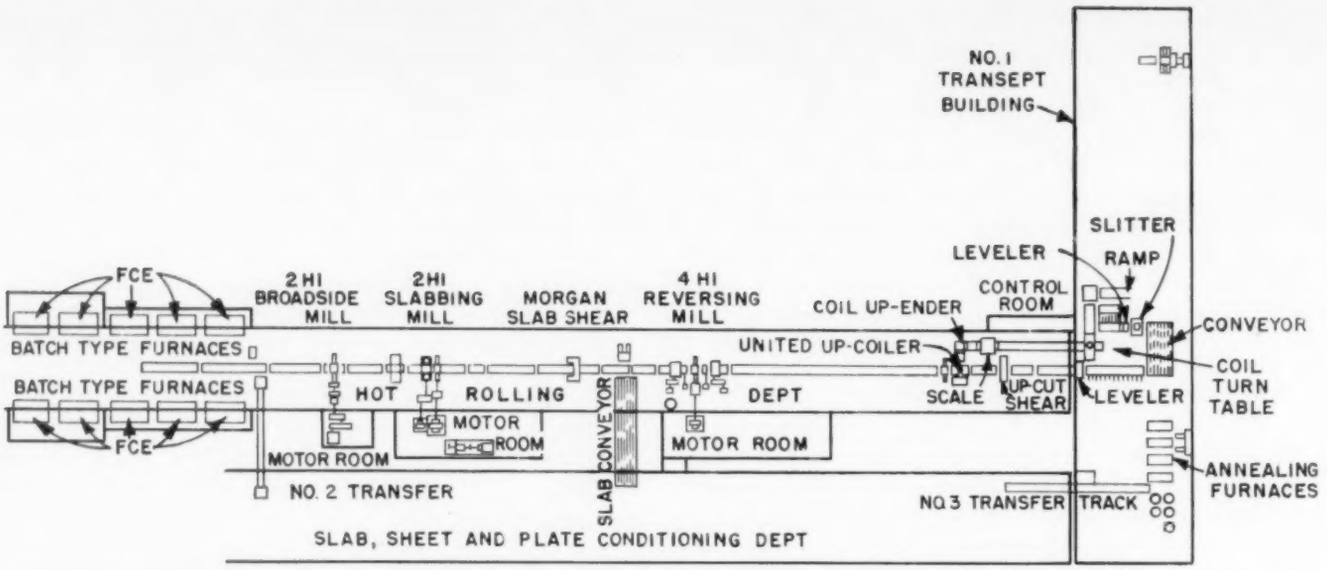


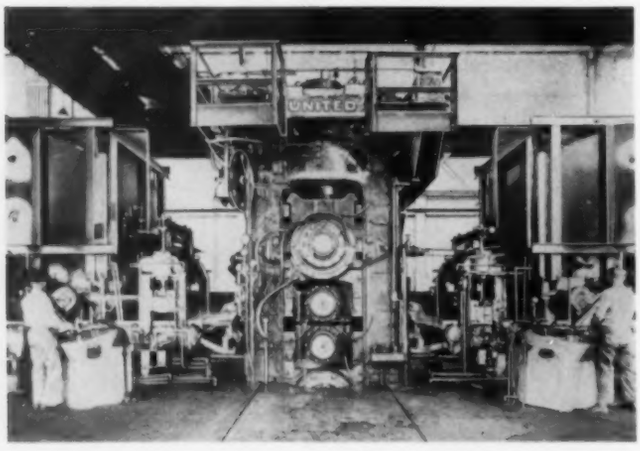
Figure 2 — Layout of a reversing hot strip mill shows a 2-high slabbing mill used as a reversing rougher and a 4-high mill as a reversing finishing mill.

must be rolled hot or gage from front end to tail end will vary widely. One obvious solution would be to eliminate the entire finishing train and devise a method to keep the steel warm and roll it all the way down to strip on the universal mill. This would keep capital invested to a minimum. The present reversing hot strip mill is one method of doing this. Someday there may be others.

BRIEF HISTORY

Inventors, primarily Abram P. Steckel in Youngstown, Ohio, tried to interest the steel industry in a single stand mill flanked by furnace coilers which would break down slabs into hot rolled sheet width coils nearly 30 years ago, but at this time the industry was just witnessing the first successful operation of a wide continuous multi-stand hot strip mill. These wide continuous mills became such prodigious producers, that despite their tremendous cost, there was enough overflow of coils to supply everybody at a price usually almost of subsidy proportions. Because of this the idea of a single stand reversing hot strip mill fell on "thorny ground" and it was not until 1931-32 that a trial was made at the Youngstown Sheet and Tube Co., Brier Hill. This unit was later moved to Indiana Harbor for a short time where it operated successfully and then was moved to Dominion Foundries and Steel, Hamilton, Ontario, Canada where it operated for 20 years. It is on a standby basis, as of last year, since they have installed a similar bigger and faster mill. In 1936 McLouth Steel, Detroit, installed a 20-in. mill and this is still operating. In 1940, a 50-in. mill was built in Germany and in 1944 a 48-in. unit, formally the rougher at Indiana Harbor, was sent to Mexico and converted into a reversing hot strip mill for Altos Hornos. This unit since has again become a rougher.

Figure 3 — Front view shows the Crucible Steel Co. 66-in., 4-high reversing hot strip finishing mill placed in service in 1949.



This is not a very auspicious showing to this point, but after World War II some of the small producers began to look again at this mill because of the new economic climate. Some reasons were: (1) the large integrated steel mills were using more and more of their own "hot bands," and the small non-integrated producer no longer had any assurance that he could continue to buy coils from his bigger neighbors at a price permitting survival if the going became difficult; (2) the capital outlay for a continuous hot strip mill staggered their imagination; and (3) the increasing freight rates and decentralization of industry encouraged the idea of smaller steel plants.

Whatever the reason, notice in Table I that electric drive equipments for eleven new mills of this type have been supplied by American electrical manufacturers in the last five years. True enough they still constitute a small percentage of our total strip capacity considering that we now have about 34 continuous or semi-continuous hot strip mills capable of producing over 40,000,000 tons of strip per year in the United States and there still are only five reversing hot strip mills with a total capacity of less than two million tons.

WHAT IS THE FUTURE?

There appears to be a place for this mill which is coming into its own after so many years. Steel plants which think in terms of less than 500,000 tons of strip

per year give serious consideration to a mill of this type. Specialty producers feel this mill has the same type of flexibility that justifies reversing cold strip mills over the continuous mills. Any product apparently can be rolled on it, at almost any temperature, with almost any draft. It can be used for carbon steel, alloy steel, 0.060-in. strip or ½-in. plate. It is claimed to produce better edges because they are kept hot, better and thinner gage, and better surface mostly for the same reason.

and high carbon strip and plate, tool steel, high manganese steel, disk and plow steel in all widths, grades and forms. To do this the mill was laid out to permit either rolling ingots into slabs, or reheated slabs to strip on all grades of steel. Some grades of steel can also be rolled direct from ingot to strip without reheating.

This mill was designed to process 27,000 tons of ingots monthly. Referring to Figure 2 the first mill on the line is a 2-high, 32 × 72-in. broadside non-reversing mill with a 1500-hp drive. This mill is used for scale

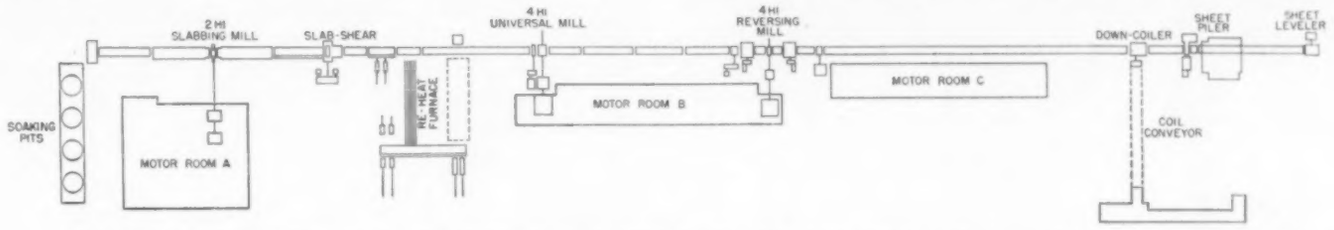


Figure 4 — This reversing hot strip mill installed in Europe consists of a 2-high slabbing mill, a 2-high universal mill with edger and a 4-high reversing, hot strip, finishing mill.

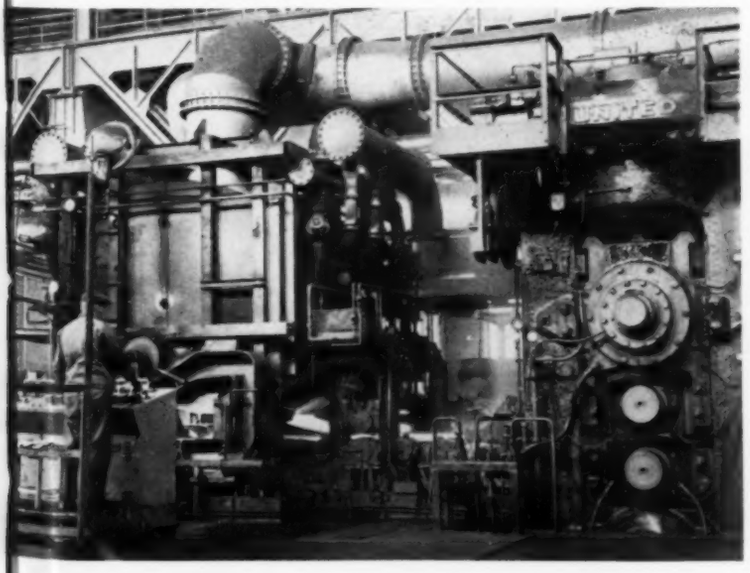
DESCRIPTION OF RECENT INSTALLATIONS

Table I lists all the reversing hot strip mills that are presently installed and operating which have had electrical equipment supplied by American electrical manufacturers. There are several others in Europe about which we have little information. A brief description of the physical layout and operating practices of a few of these mills should be helpful in laying a foundation for the electrical considerations which will be discussed in detail later.

66-IN. MILL AT CRUCIBLE STEEL CO.

The first mill to go into operation, of these eleven mills which have been built since the war, was the 66-in., 4-high mill installed at the Midland, Pa. Works of the Crucible Steel Co. of America. This mill was designed with maximum flexibility for widely diversified products such as stainless steel strip and plate, mild medium

Figure 5 — The Luxembourg 66-in., 4-high reversing hot strip mill was placed into service in 1950. The large pipes overhead are used to supply blast furnace gas to the coiler furnaces.



breaking and cross rolling of slabs to increase their width. The next mill is a 2-high, 32 × 69-in. reversing slabbing mill with a 5000-hp drive. This mill either reduces ingots (ranging from 9 × 15 to 20 × 55 in. weighing from 1100 to 24,000 lb) to slabs or reduces reheated slabs to strip plate, or on occasions reduces ingots to strip plate. It has a 28 × 30-in. vertical attached edger operating in conjunction with it, driven by a 2500-hp motor. Next in line is a shear suitable for cropping either slabs or strip plate. The "coil mill" or hot finishing mill is a 66-in., 4-high with hot upcoiling gas fired furnaces, with a 5000-hp main drive and (as now revamped) 300-hp furnace coilers. Steam and high pressure water sprays are used to descale. The strip is delivered by individual, d-c motor-driven runout tables to an upcoiler with driven mandrel. If plate is the final product, a by-pass permits it to continue to a 60-in. upcut plate shear. Figure 3 shows a front view of the reversing hot strip finishing mill. This picture shows the operator's pulpits to be very close to the furnace coilers. This location proved to be too hot for the operators and they have since been moved back. More about pulpit location will be covered later.

66-IN. MILL AT LUXEMBOURG

The 66-in. mill in Luxembourg shown in Figure 4 has several unusual features. The first mill in this line is a 2-high, 44 × 108-in. reversing slabbing mill with a 7000-hp, 40/80 rpm twin drive. Here ingots up to about 20,000 lb are reduced to slabs 3 to 4 in. thick. Slabs are cropped at the slab shear and proceed to a 2-high, 42 × 66-in. reversing universal mill driven by a 5000-hp, 40/80-rpm, d-c motor with an attached 2-high edger, driven by a 500-hp 100/315-rpm motor. Here the slabs are rolled down to strip plate ⅝ to ¾-in. thick in five to seven passes and sent to the finishing mill.

This layout is unusual in that it has both a slabbing mill and a universal mill. This was done because this mill was designed primarily to roll mild steel from Thomas converters (a basic bessemer process) from the ingot to strip without any reheat on all orders. It was felt that to be assured of this it would be necessary to

have a slabbing mill with the best features of a slabbing mill, and likewise a universal mill with the best features of a universal mill in order to roll from the ingot to the strip plate in a minimum of time. It was decided that to make one mill do both functions would necessarily be a compromise and would cause enough delays on some schedules that reheating would be necessary. Provisions were made for a reheat furnace to reheat the occasional order or to reheat slabs which cooled due to delays. The two mills are driven from a common motor-generator set with provisions for switching by contactors to the mill selected by the operator. The mill without power is automatically switched to a small exciter (normally used to dynamic brake the motor-generator set) to keep it turning slowly to prevent uneven cooling.

The finishing mill shown in Figure 5 is very similar to the Crucible mill except it has a separate crop shear ahead of the mill which crops front and rear of the strip plate on the fly. The large weird looking pipes over the mill are necessary because blast furnace gas is used to heat the coiling furnaces and with only about 100 Btu per cu ft it takes a lot of gas to heat these furnaces to approximately 2100 F. In this mill, as before, five passes or so reduce the strip to a minimum of 0.060 in. after which it is run out on individually driven table rolls to a down coiler if it is to be coiled. If it is to be sheared, a flying shear is located immediately after the mill and can be selected by the mill operator to automatically cut on the last pass. These sheets then pass over the coiler and go into a piler. If plate is produced, the piler is withdrawn and a table section carries the plate to a cooling bed and shears.

This mill has handled the entire capacity of the steel plant which on occasions has been about 35,000 tons per month and could handle more. As a matter of fact the steel comes to the finishing mill so hot on occasions that they have found it necessary to install an automatic temperature monitor to hold strip plate until it has cooled to the proper temperature, before it can enter the finishing mill.

60-IN. MILL AT DOMINION FOUNDRIES AND STEEL CO.

The latest and probably most modern (if we can assume that each mill is an improvement over the last) reversing hot strip finishing mill has just gone into production at Hamilton, Ontario, Canada. With the operating experience of twenty years on their old mill, they went into production with a minimum of delay. The first mill in this line is a two high universal mill used as a primary rougher which rolls from the ingot to strip plate, after which it is forwarded immediately to the 60-in., 4-high reversing finishing mill. The head and tail are cropped before rolling. After five passes it is run out and coiled or, if plate, crosses the cooling bed and is sheared.

These three examples illustrate the pattern of reversing hot strip mill installations. However, to be complete it should be pointed out that one major innovation used by at least two mills is to incorporate an oscillating roller hearth type furnace in the line. This furnace, about 150 feet long, is located between the roughing mill and the finishing mill. Primary objective of the unit is for equalization of temperature on the plate before reduction to hot strip gages so a more uniform gage lengthwise will be obtained in the finished material. It has also been used to hold the second half of a piece of strip plate while the first half is being rolled, in cases where the finishing mill cannot handle the entire slab at one time.

ROUGHING MILL

The selection of the electric equipment for reversing roughing mills has been well covered by previous articles and will not be discussed in detail here. There are however several additional electrical considerations which must be kept in mind, if a slabbing mill and a reversing universal plate mill are to be mechanically combined into one mill. Table II shows a typical schedule on a mill of this type where a 26 × 47 × 66-in. 19,600 lb ingot is reduced to a 0.65 × 32.13-in. strip plate in 37 passes. This wide range of roll openings causes two major problems. One, it is difficult to mechanically design a mill which will roll steel flat through this wide range of sizes. In other words the end may turn up or turn down as it leaves the mill. There is every reason to believe that if a twin drive (separate top roll and bottom roll motor) is supplied on such a mill, the ability to quickly control the load division between the top and bottom rolls may help this problem considerably. Special thought then should be given to arranging the armature and field circuits so this can be most easily accomplished.

The second problem is the wide range of screwdown operating speeds. This will be discussed in more detail along with the screwdown control for the finishing mill.

Another problem occurs when a combination slabbing mill and plate mill includes an attached edger, because of the wide range of drafts which are taken in reducing an ingot to a plate. This wide range of drafts makes it necessary that the operator either readjust the draft compensation as he rolls, or if he uses a "top speed selector," the draft compensation can be "programmed" into the control by this selector switch on the premise that the higher the speed, the thinner the material and therefore the greater the per cent of draft.

The selection of the edger motor could cover a complete article in itself and will not be gone into in detail at this time. Of course particular attention should be given to the selection of the edger motor rating on any mill to obtain best overall mill performance, but on a combination mill of this type because of the wide range of operating conditions, a poor selection is even more noticeable. For ideal results an edger motor should always be so selected, specified, and designed to accelerate and decelerate with the mill, with equal percentage rated current on each drive. This can only be done with motors selected with care as regards to horsepower rating, base speed and speed range. Obviously an edger motor with inadequate horsepower, higher base speed and with more speed range than the mill motor can not be expected to keep up with the mill. The only alternative in such a case is to slow down the mill to match the performance of the edger. It is quite likely that the ideal performance of an edger may be too expensive to be justified. Conversely it is quite likely that the least expensive edger motor will so greatly handicap the mill operation that it can not be justified. Only a clear understanding of the limitations of various edger motor combinations by the ultimate user, mechanical manu-

facturer and the electrical manufacturer can help all parties concerned evaluate the factors of cost versus performance.

The other problems are essentially the same as other reversing slabbing mills and will not be discussed further.

FINISHING MILL MAIN DRIVES

The main drive motors for reversing hot strip finishing mills have rather special requirements. They need some of the characteristics of the reversing blooming and slabbing mill, and some of the characteristics of the continuous hot strip finishing mill motor. The characteristics of these two types of motors are quite different with the first normally designed for low base speed, low WK^2, 275 per cent maximum torque, 50 C temperature rise, and rugged reversing service, while the second has higher base speeds, high WK^2, 200 per cent maximum torque, 40 C temperature rise, and non-reversing service. In general the motors used have been selected with high base speeds (from 70 to 230 as shown in Table I) in order to get reasonable strip speeds on the later passes without requiring motors with field control greater than 2 to 2½ to 1. Although some of the motors were built with double armature construction, it was not done primarily for low WK^2 but because of design limitations in designing motors of such high horsepower and speed in a single armature. About 275 per cent maximum torque is normally furnished so as to provide enough torque for slow speed breakdown passes and also to provide margin for accelerating under reasonable loads to higher speeds on the later passes. Temperature rises of 50 C with Class B insulation is standard, although there is no reason why a 40 C motor would not be just as suitable. The rugged mechanical construction of reversing slabbing and blooming mill motors is standard, although the service is not quite as severe, because it is never accelerated, decelerated or reversed nearly so fast. The rate is limited primarily by the ability of the coilers to maintain tension during rapid speed changes.

To calculate accurately the proper horsepower and speed of a motor for a new mill requires that specific rolling schedules, and power requirements be available for similar material rolled under similar conditions. These data and schedules are not as well established for a mill of this type as for the more common strip mills and most likely will not be available. Common practice is to use the same methods to calculate the horsepower for this mill as would be used to calculate a normal blooming mill motor taking into account all the operating conditions of: accelerate to thread, run at thread, accelerate to run, run, decelerate to stop and idle time. The thread or entering speed will vary on different mills, but about 300 fpm minimum and 500 fpm maximum would be average values. This speed will last until the winding furnace coiler has about one wrap, then the mill accelerates to a top speed determined by its torque ability and rms heating at a rate of about 200 to 300 fpm per sec. The maximum speeds average about 1200 fpm as can be seen from Table I and have been built for as high as 2050 fpm. The maximum permissible loading on the motor will be determined by two things — the maximum commutating ability and the rms heating. Figure 6 shows the maximum occasional and frequently repeated values of torque and horsepower for various speeds. Each application of overload of course must be followed by a period of light load such that the rms heating of the complete cycle does not exceed the motor rating.

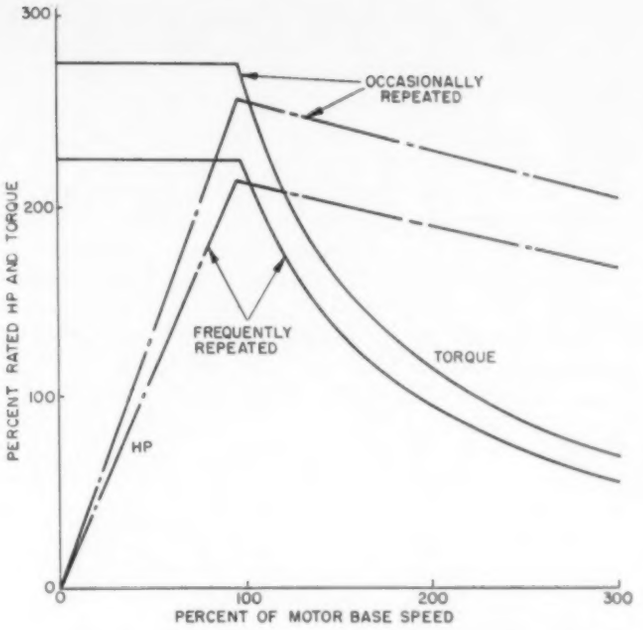


Figure 6 — Maximum hp and torque ability of typical reversing hot strip mill main drive motor are given.

Figures 7, 8 and 9 show a typical set of recording charts taken on the ARBED universal rougher and finishing mill. Notice the long delay in getting up to speed on the last pass. This apparently was a safety precaution taken at that time to prevent occasional cobbles in the down coiler when entering at high speed. It is believed this has since been remedied and is no longer necessary.

MAIN MOTOR-GENERATOR SET SELECTION

The selection of the main motor-generator set is straightforward enough. Obviously the generators should be selected to match the motors with the same overloads, etc. Because of the long passes which make a flywheel practically useless, a synchronous driving motor is the natural choice. The speed and number of units is a matter of economics. There is always an optimum combination for lowest first cost, and another combination which in many cases will simplify the spare parts problem. This should be studied in line with the spare parts practices of the particular installation.

In several instances, the main motor-generator set which supplies the finishing mill also is used to supply the slabbing mill. Here again, as is the case where two roughers are supplied by a single set, an auxiliary source to idle the undriven mill is almost a necessity. (See Figure 10 for a typical motor-generator set installation photo.)

Because most of these mills are installed in small steel plants where the electric system is quite likely to be small, a power factor regulator working to hold either constant power factor or rkva to the synchronous motor

can quite often be applied to good advantage. This regulator normally is the rotating type which by means of a phase shifting transformer network compares the magnitude of two control voltages. When these are equal, it means either the angle between the voltage and current is constant as in the case of the power factor regulator or the reactive volt amperes are constant in the case of the rkva regulator. This regulator then tends to reduce the excitation to the synchronous motor when it is unloaded, and to add excitation when load comes on so that additional pullout torque is available when needed. From this it is evident that in addition to helping the power system, a power factor or rkva regulator could be used to allow synchronous driving motor with less than 275 per cent maximum continuous pullout torque to be supplied on the motor-generator set. So far as the author knows this latter use has never been made on reversing hot strip mills. It has the one obvious disadvantage that if the regulator is not working, the mill can not run except at greatly reduced capacity. This may not be an argument, however, since the main drive control likewise consists of many regulators, the loss of any one of which would most likely shut down the mill. The economics of using a synchronous motor with less than the maximum required continuous pullout torque should be investigated in some case, especially where a power factor regulator is needed to help the power system.

MAIN DRIVE CONTROL

The main drive control is fundamentally the same as that used on reversing slabbing mills, in that it consists of a rotating voltage regulator for the generator and a rotating motor field current regulator for the motor. See Figure 11. The load current limit acts to strengthen the motor field if weakened excessively. The pumpback or regenerative current limit acts to hold up generator voltage should it tend to decay too quickly. The fast reversal speeds are not required or usable on the finishing mill, and therefore provisions must be made to accelerate and decelerate the mill slowly but still have the limit circuits alert and responsive. Some mills have used a motor operated rheostat to program the generator voltage and motor field during acceleration and deceleration to insure linear speed changes. This method has some merit in that it makes it very simple to obtain linear changes in speed. The disadvantage of course is the wear and tear on a rheostat which must run through its range on every pass. It has, however, not been the author's experience that it is necessary to resort to this method to provide linear acceleration. Other means of controlling the build up of the generator voltage and the motor field current have been developed which give satisfactory results.

Particular pains should be taken to provide a constant thread speed which will be independent of loading on the main motor. This is important so the operator can estimate starting time for the coilers, and even more important if automatic coiler starting is used. This thread speed incidentally should be independent also of the a-c system frequency. This may sound strange but there was an instance where a mill was installed in a plant in Europe and at odd times the frequency of the

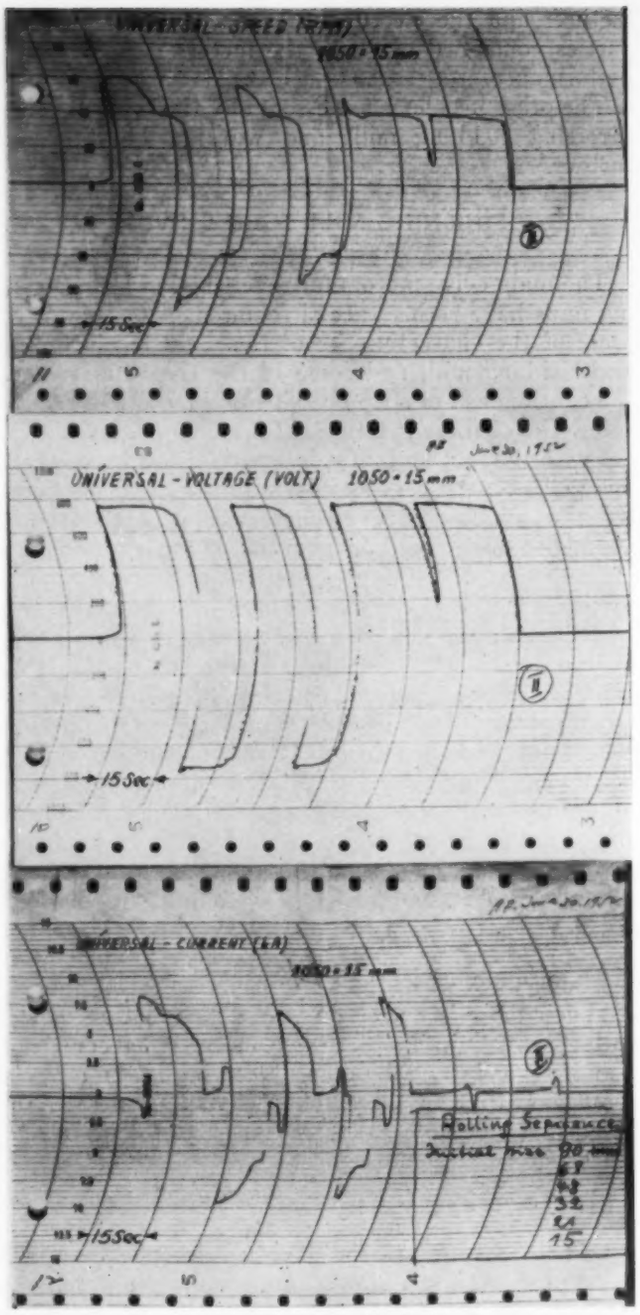


Figure 7 — Recording charts for ARBED universal rougher and 4-high reversing hot strip finishing mill show rolling of 15 mm strip.

power system would vary. This would allow the reference pilots to change speed and the mill would obediently follow this speed change. As a result the time relays for automatically starting the coilers would be wrong and cobbles result. Two approaches are open in this case: (1) work a speed signal into all time relays to recalibrate them for mill speed change or, (2) drive the pilot machines from a source independent of frequency variation. Both methods have been used and found to work equally well.

REVERSING HOT STRIP MILL AUXILIARIES

Probably no other mill depends on the proper selection, design, construction and coordination of the auxiliary drives for successful operation as does the reversing hot strip mill. Poor performance of any one of these

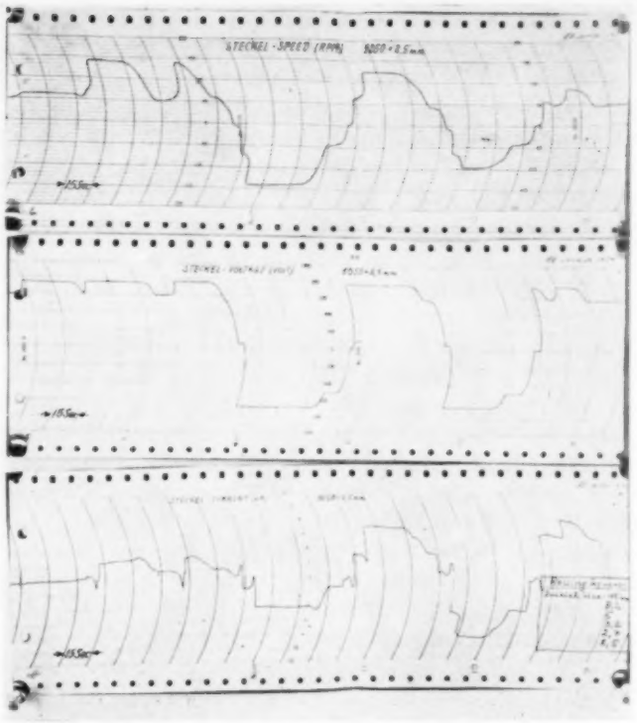


Figure 8 — Recording charts for ARBED universal rougher and 4-high reversing hot strip finishing mill show rolling of 2.5 mm strip.

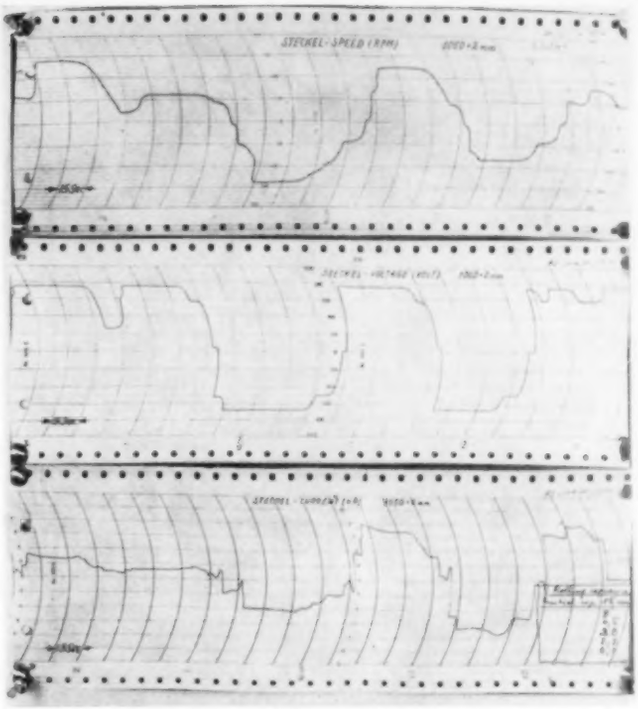


Figure 9 — Recording charts for ARBED universal rougher and 4-high reversing hot strip finishing mill show rolling of 2.0 mm strip.

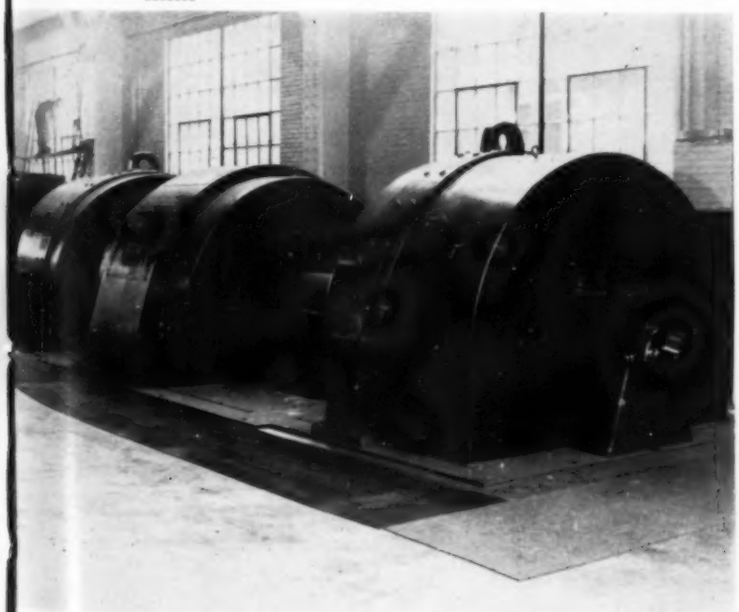
auxiliaries can cause the entire mill to be inoperative. For this reason considerable thought must be given to the selection of sturdy, reliable motors and flexible, well coordinated control.

The best practice is to use the tried and proved mill type auxiliary motor where the rating is available. Where the rating is too high, such as on the larger coilers, especially built steel mill motors should be supplied. For the tables and rollers, special steel mill runout table motors are recommended. It is modern practice to use totally enclosed non-ventilated construction in all cases except for the coilers and pinch rolls where forced ventilation has advantages.

It is also normal to supply all units which must synchronize their speed with the strip such as coilers, pinch rolls and groups of table rollers, as individual adjustable voltage systems, each generator to be controlled by a rotating type voltage regulator to operate at a voltage proportional to the mill speed. The screwdowns, side guides, and shears can be either adjustable voltage or constant potential depending upon the mechanics involved and will be discussed in detail later.

The selection of the adjustable voltage auxiliary motor-generator set is straightforward and similar to that on any other hot strip mill. The ratings of the generators for purposes of duplication, and the grouping of the generators for purposes of using their diversity in selecting the driving motor must be kept in mind. In other words the runout tables and coiler will not be loaded when the delivery furnace coiler is being used, nor will the delivery furnace coiler and the entry furnace coiler be loaded as a motor at the same time. By juggling the generators around a best arrangement, considering both cost and duplication, can be selected.

Figure 10 — This main motor-generator set is used for supplying power to a 66-in., 4-high reversing hot strip mill.



FURNACE COILERS

Successful operation of a reversing hot strip mill is probably more dependent upon the successful performance of the furnace coilers than any other item. They must be able to receive the hot strip from the mill, establish tension in a minimum time, accelerate, run, decelerate as a winding reel, accelerate, run, decelerate as an unwinding reel, all with a minimum of misoperations. Many and varied have been the mechanical designs of coiler mandrels. The earliest successful design consisted of a rotating drum-like device with multiple

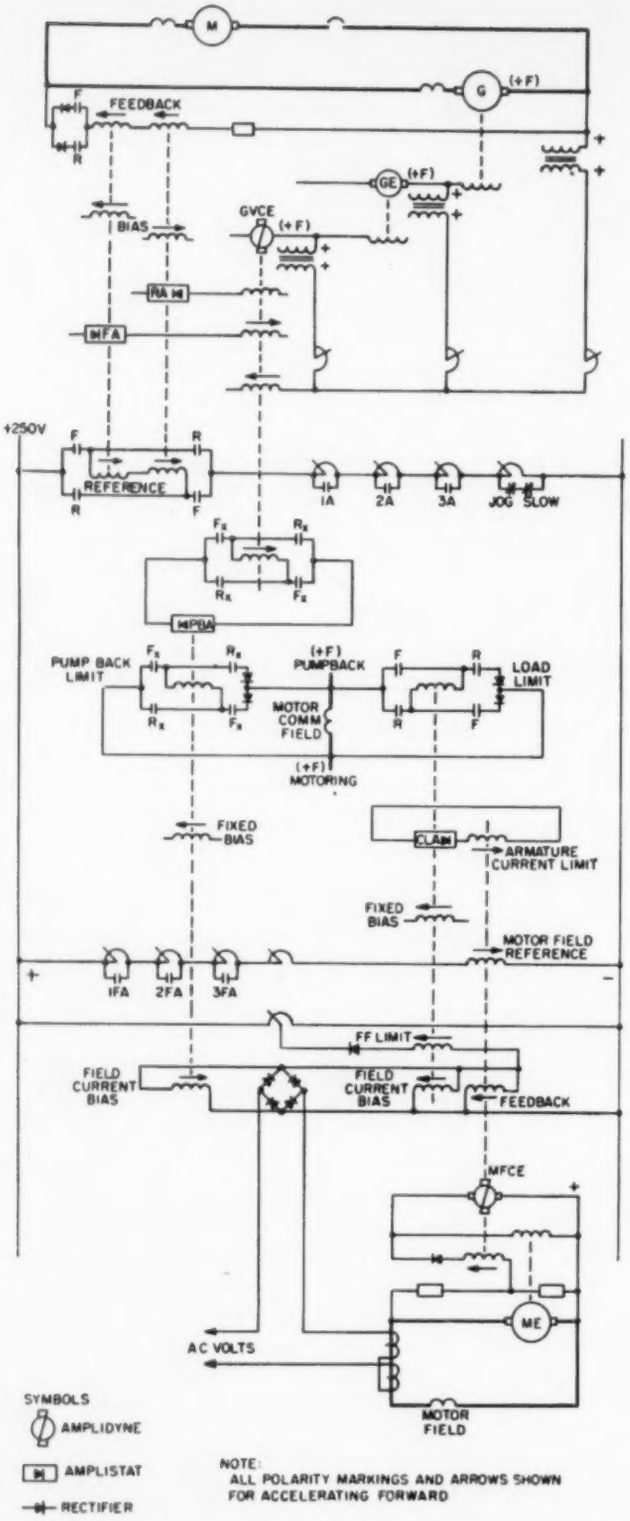


Figure 11 — Simplified schematic diagram for the main drive control for a reversing hot strip mill.

slots (as shown by part A, Figure 12) which rotated continuously toward the mill during threading. When the strip approached from the mill, the deflector gate was raised and if the strip entered one of the slots it was quickly bent sharply around one of the "paddles" securely locking it on the mandrel. Within one revolution, tension was established and the mill accelerated. This "multiple slot — continuous running — reverse rotation" design is still in use on one mill (No. 10, Table I). The major problem with this design was to build the paddle points strong enough so as not to distort from high tension and temperature — yet thin enough mechanically so the law of averages would not too often cause the strip to bump head on into one of these edges and fail to enter. The thicker the edge the more often this happens. However, with alert operators, rarely does such a cobble mean the loss of the strip.

The next step, in an effort to eliminate these occasional cobbles and also to decrease maintenance, was to design a drum type mandrel with a slot in it (similar to that shown in part B, Figure 12). This coiler of necessity must stop and position after each pass with the slot in the proper position to receive the end of the strip. When the strip enters the slot, the mandrel starts running toward the strip, overspeeds to remove the slack accumulated while the coiler accelerated, bends the strip sharply around the edge of the coiler, and after about one wrap establishes tension and accelerates with the mill. This design mechanically is strong but does have stress problems caused by the mechanical unbalance and uneven heating and cooling. To overcome these disadvantages the trend seems to be toward the dual slot (a sample of which is shown as part C). This "dual slot — start stop — reverse rotation" design seems to be the most popular at the moment.

There is, however, another type in use on at least two mills; the "single slot — start stop — forward rotation" design (shown in part D). In this design the strip is apparently jammed around the hook in the slot before starting, and by the use of a roller, the speed of the strip and the coiler is kept synchronized for the first wrap so the strip can not pull out. The object of the forward rotation is to reduce the amount of loop that is formed before tension is established and thereby decrease the probability of cobbles.

Still another coiler design and the simplest to control electrically is shown as part E. This "no slot — continuous running — forward rotation" design is essentially a modern mandrel driven hot strip up-coiler with a furnace wrapped around it. This coiler has no such problems as accurate starting, fast acceleration for minimum loop, overspeeding to remove loop, slowing down before strip snaps, etc. Here the problems are to establish tension before several wraps are made and to reduce the high mechanical maintenance of all the rollers and guides located in such an ambient. However, this coiler originally supplied on mill No. 9 failed to give the desired performance, and has now been replaced by a "dual slot — start stop — reverse rotation" design.

MOTOR SELECTION

Motors on furnace coilers are always too small. No matter the size selected in the past, the operators want them larger. This at least has been the case on all mills up to No. 13, Table I with which the author has been familiar. Here, however, notice the 0.587 "hp per 100 fpm per in. mill width" is the highest "pull per inch" of all the mills listed. It was here that the operators agreed for the first time that plenty of pull was available on the heavy passes, and it was even found necessary to reduce the pull on the thinner passes. The average of the 13 mills listed in Table I shows 0.310

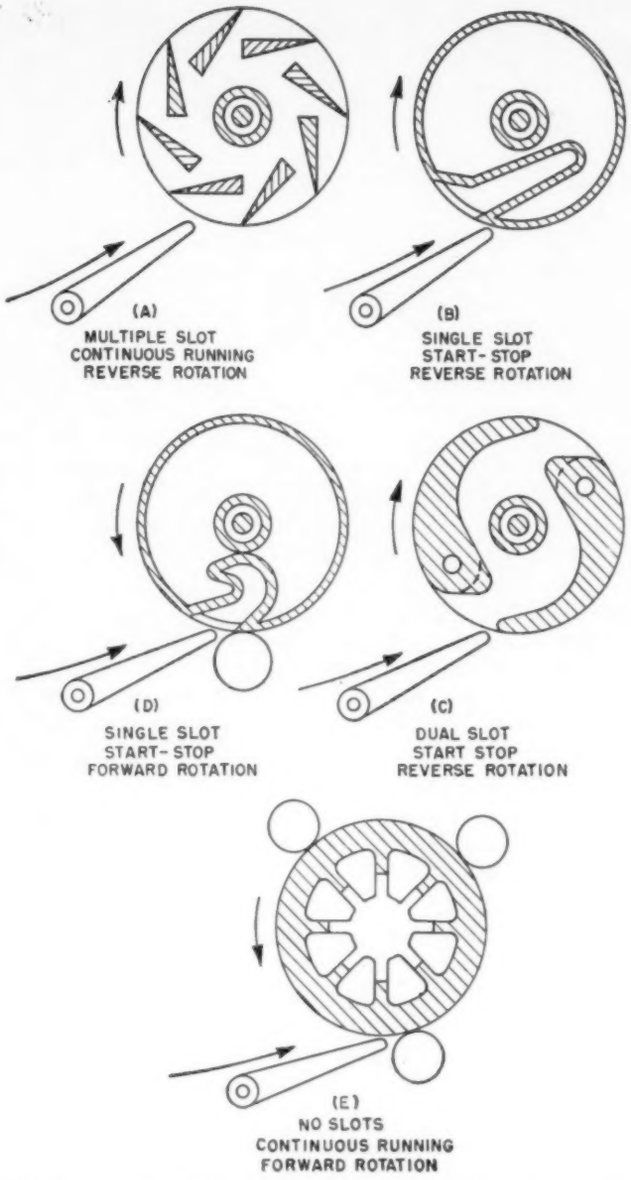


Figure 12 — Mandrel construction is given for various types of furnace coilers.

hp per 100 fpm per inch mill width. This corresponds to a pull of $\frac{0.310}{100} \times (33{,}000) = 102.3$ lb per in. mill width. If it is assumed that most people who have these mills would like more horsepower on the furnace coilers, a good estimate for a suggested "rule of thumb" might be 0.5 hp per 100 fpm per in. mill width or a pull of $\frac{0.5}{100} \times (33{,}000) = 165$ lb per in. mill width.

The standard mill auxiliary motor is ideal for this service. It is a proven, rugged, low WK^2 motor, with a high ratio of peak to average load torque. The motor should be force-ventilated to obtain the one hour, 75 degree C rise rating continuously. This motor is available in ratings from 5 to 500 hp. For motors larger than 500 hp it has been the practice to supply special d-c motors such as are used on reversing reels throughout the steel industry. This motor should be specified as a mill type motor and should provide the following features:

1. Low WK^2.
2. Class B insulation on armature and field.
3. 60 degree C rise continuous force ventilated.
4. No more than 2 per cent speed regulation at top speed nor more than 2 per cent times speed range at base speed.
5. 200 per cent load peaks occasionally applied from base speed to 200 per cent base speed and 175 per cent at and above 300 per cent base speed.
6. Frequently applied loads 175 per cent at base speed, 160 per cent at 200 per cent base, and 140 per cent at 300 per cent base and above.

Another desirable characteristic for the furnace coiler motor which is not necessarily standard on all mill type reel motors is inherent stability. This means stability both as a motor and as a generator for either rotation without requiring series fields to be switched. Sometimes this requirement requires a sacrifice in other characteristics, such as WK^2 and may be relaxed slightly in certain cases where the armature resistance can be depended upon to insure stability of a motor with a slightly rising speed characteristic.

SPEED RANGE

Furnace coiler mandrels in general have large diameters in comparison to the maximum coil diameter, or in other words, the coil buildup is small. It is quite common to have 48-in. mandrels and 60-in. maximum coils. Other mills list 48-in. mandrel with 72-in. maximum coil, 900 mm (35.5-in.) mandrel with 1300 mm (51.2-in.) maximum coil, etc. These examples show that a shunt field range of 1.25:1 to 1.5:1 in the motor is all that is required for buildup. This range multiplied by the ratio of $\frac{\text{maximum work roll}}{\text{minimum work roll}}$ (assumed equal to 1.1) and multiplied again by 1.1 to allow for regulator margin on the high speed end and 1.1 for the low speed ends suggests a range of $1.25 \times 1.1 \times 1.1 \times 1.1 = 1.66{:}1$ for the normal buildup, and a range of $1.5 \times 1.1 \times 1.1 \times 1.1 = 2{:}1$ for the widest range.

These relatively small speed ranges suggest that this mill would be a natural for a furnace coiler with two tension ranges — a high range for the first slow speed heavy passes and a low range for the later high speed light passes. Any such scheme would require that a motor with a wider speed range by shunt field be supplied. For example, for the first case where we had 1.25:1 coil buildup we could obtain double tension up to half speed by providing a motor of the same horsepower with a shunt field range of $1.25 \times 1.1 \times 1.1 \times 1.1 \times 2 = 3.33{:}1$. This obviously must not be carried to extremes. Widening the speed range to obtain three times normal tension to one-third top speed would require a shunt field range of $(1.25 \times 1.1 \times 1.1 \times 1.1 \times 3) = 5{:}1$ which would not be a good motor for a fast accelerating reel of this type. Conversely, if the buildup is so great that with a motor with a field range of 3:1 the increase in tension is only say 1.25 times normal up to 80 per cent speed, the gain is probably not commensurate with the complications necessary to the control.

If it is assumed that a motor with a 3.33:1 motor field range is suitable to provide double tension up to

50 per cent mill speed, the control would require some switching so that for the high tension range, the mill top speed would be limited to 50 per cent top speed; the reel generator voltage would be recalibrated to supply 100 per cent reel motor voltage at this reduced top speed, and the minimum motor shunt field limit must be recalibrated to a stronger field.

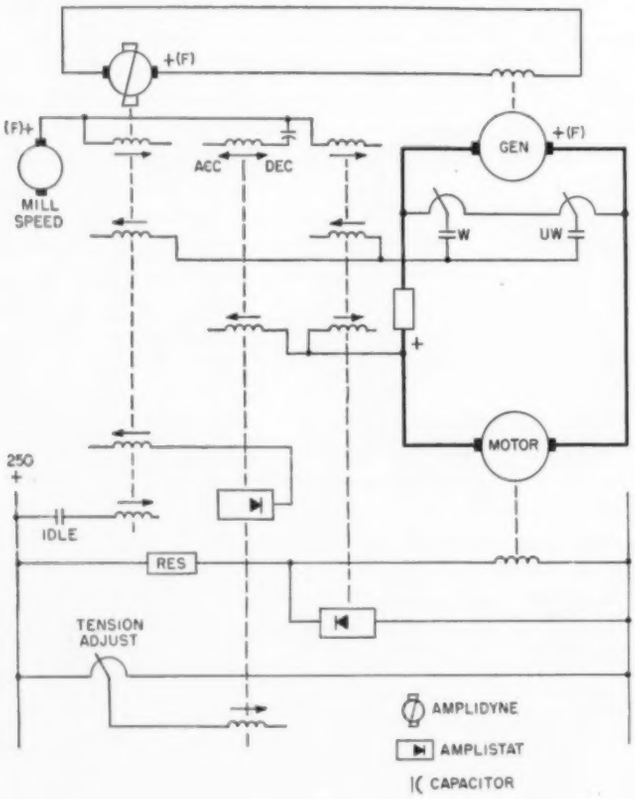
To my knowledge this dual range of tension for the furnace coilers has never been supplied on a mill of this type and some troubles might be encountered in adjusting the transient characteristics for the two different conditions, but on future mills with reasonable ranges of coil buildup such as 1.25:1 this possibility should not be overlooked.

CONTROL

A furnace coiler like all other coilers must first and foremost hold constant tension during coil buildup; so say the mechanical men and the metallurgist. This complicates the problem. It would be much simpler if the control could be designed to supply constant torque at the motor shaft and allow the tension to change by the ratio of the buildup — in other words, as a 48-in. mandrel changes to a 60-in. coil, the tension would decrease by $\frac{12}{48}=25$ per cent. However, this decrease in tension has never been permitted. Therefore, it is necessary to design a system for the coiler which will hold constant tension for all mill speeds and coil diameters. A well known fundamental relation in mechanics states:

$$1.\quad \frac{\text{Strip tension (lb)} \times \text{strip speed (fpm)}}{33{,}000}=\text{hp}$$

Figure 13 — Simplified schematic diagram for the furnace coiler control.



From this it is apparent that if the coiler hp is held proportional to strip speed the tension will remain constant.

Another fundamental relation is:

$$2.\quad \frac{\text{Volts} \times \text{amperes} \times 1.34}{1000}=\text{hp}$$

Therefore combining equations (1) and (2):

$$3.\quad \text{Volts} \times \text{amperes}=\frac{\text{Strip tension (lb)} \times \text{strip speed (fpm)}}{1.34 \times 33}$$

This equation states that if the voltage of the coiler motor is held proportional to strip speed the coiler motor amperes will be proportional to strip tension. Therefore, one obvious means of holding constant tension would be to regulate the coiler motor voltage to be proportional to the strip speed by one regulator and for any strip speed to regulate the coiler motor amperes constant throughout the coil buildup by changing the shunt field on the motor by another regulator. This method has been used and successfully. However, there are some advantages in arriving at the same result by a slightly different method. Figure 13 shows a simplified schematic diagram for a furnace coiler control which illustrates this method. To simplify this diagram, miscellaneous auxiliary functions, limit circuits and anti-hunt connections are omitted. Here the tension (current) is regulated constant by changing the voltage applied to the coiler motor by one regulator. A second regulator checks this voltage to see if it is proportional to strip speed and if not changes the coiler motor shunt field until the proper (voltage-strip speed) relation does exist. During steady state running conditions either method produces the same results. The method shown in Figure 13 has some distinct advantages during transient conditions which makes it easier to meet some of the other requirements for a good furnace coiler.

A second and important requirement is that the coiler hold tension during acceleration and deceleration of the mill. This is accomplished by measuring the rate of change of mill speed from the mill pilot generator and using this signal to recalibrate the hp output of the reel motor by recalibrating either the voltage regulator or the current regulator or both, during this transient, so as to supply the necessary extra energy to accelerate the coiler and still maintain normal tension.

A third requirement is that these regulators be stable during normal operations. This is one of the most difficult differences between a coiler for this service and coilers for, say, a cold strip mill. When the coiler starts it must get up to speed fast while a minimum of loop is forming. After the loop is removed and tension is established, a "bump" of considerable magnitude is formed where the strip is hooked into the slot. This bump excites the regulator at a frequency which it can not hope to follow and can only become upset if it tries. Therefore, the regulator must be so adjusted that it will respond fast on starts, but will not try to follow changes due to the eccentricity of the coil.

These apparent contradictory requirements are met by establishing two sets of operating conditions. First, when the empty reel starts:

1. The voltage regulator is adjusted to have minimum damping.

2. The voltage reference is set to call for a value higher than required for steady state conditions.
3. The current regulator is inoperative.

With the above conditions, the coiler starts and accelerates at its maximum rate.

Second, at a predetermined point, a relay operates to set up a new set of conditions:

1. The voltage regulator is given proper damping for steady state stability.
2. The voltage reference is changed to the proper value which will synchronize the coiler with the strip speed with a minimum disturbance.
3. The current regulator is brought into play to regulate the pre-selected steady state tension.

By proper adjustment of the magnitude and duration of the above variables excellent results have been obtained.

This coiler control must also provide for slow speed "idling" which is independent of mill speed, so as to keep the coiler at an even temperature during the time it is not coiling.

Some method of draft compensation must be incorporated into the control for the uncoiler. Theoretically the motor voltage should be proportional to strip speed at all times if amperes are to be indicative of tension in the strip. But for any given delivery strip speed the entry strip speed will depend upon draft. With 50 per cent draft (reduction) the entry speed will be $\frac{(1-0.5)}{1}$ or 50 per cent of the delivery speed. With 25 per cent draft the entry speed will be $\frac{(1-0.25)}{1}$ or 75 per cent of the delivery speed. The proper way to set the voltage on the coilers would be to measure the actual strip speeds and regulate the voltage to be proportional to these speeds. This requires either rolls with tachometers or other more devious means to measure or calculate the strip speed at all times. This has never been thought to be practical, so arrangements are usually made to operate the uncoiler at some compromise value of voltage which represents average draft on the mill. A few operators have requested that this draft adjustment be placed on the desk so they can adjust it for each pass. It is doubtful if this ever is used. The present method seems to be adequate. If ever the need should arise which would require automatic true draft compensation, it could be provided with certain additional complexity by one of several methods which will not be elaborated on here.

Provision must also be made for automatically positioning the coiler with the slot in the proper position when the strip is to be coiled. It has been the practice to supply a high speed cam limit switch for indicating the proper stopping position. This has not proved entirely satisfactory on most installations, because of the maintenance required. Although there appears to be no standard device readily available at the moment, future installations should consider devising either a non-contacting limit switch to indicate the slot positions to the control, or possibly a solenoid operated mechanism to retract the contacts from the cams of a cam limit switch after the coiler has started and to relower them when the coiler has returned to the idle speed.

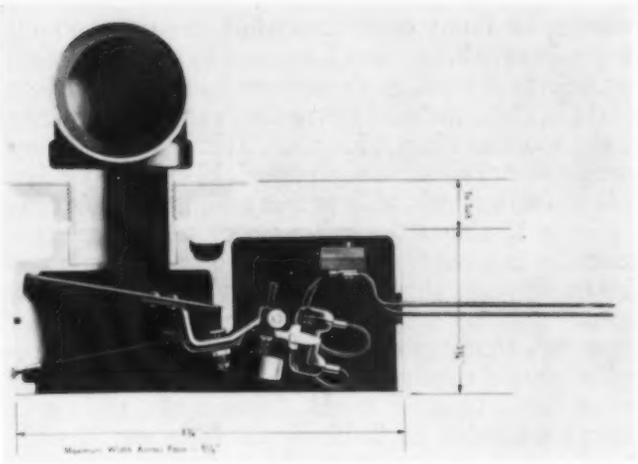


Figure 14 — Typical air flow switch is used for automatic starting of furnace coilers.

Furnace coilers in general are always supplied with some method of indicating the number of wraps on the coil. This is a convenience even if the operator can see into the furnace and an absolute necessity if he can not. One of the best systems for providing this function consists of a selsyn transmitter on the coiler, and a selsyn receiver connected through proper gearing to drive a pointer on a dial (about 2 feet in diameter) calibrated in wraps. This mechanism incorporates a cam limit switch which can be adjusted to operate at any number of preset wraps to do most any auxiliary function such as turn on warning lights, slow down mill, etc. Proper relaying and interlocking must be provided to insure that the coiler running idle does not count wraps, and it must be reset to zero after each unwind cycle to prevent a gradual accumulative error. This can usually be accomplished by holding out the position stop relay until a cam switch on the wrap counting mechanism indicates zero wraps.

For best and most predictable results on a furnace coiler of this design, automatic starting is almost a must. Three recent mills have used an air switch to start the coilers and have all given very satisfactory operation. Other types of signals have been tried including all types of photoelectric devices and have been discarded. The most simple, dependable, and accurate device proved to be the small air switch. This air switch can be located to one side of the mill and the air can be led to it through a 2-in. pipe located on the pinch roll housing. The air supply should be under the table between the pinch roll and the furnace coiler. A small "bell" or "funnel" several feet above the table and located for protection on the pinch roll mechanism housing will receive plenty of air to lead across to the air switch. This air switch can be home-made of a mercury switch and a counter-weighted vane or can be ordered from one of several supply houses. One good air switch which will operate on as little as 0.1 inch air pressure is shown in Figure 14.

Some operators, it is claimed, refuse to use such devices and refer to them as gadgets. On the three mills just referred to, if the air switch is down the mill is down. The operators refuse to roll without the air switch even though push buttons are available for

operating manually. Occasionally operators blame air switches for faulty operations which are not the fault of the air switch, but may be caused by other electrical or mechanical troubles. Consequently, on two occasions a light has been installed above the air switch to indicate to the operator when it is closed. This has proved very successful and the air switch now is blamed only when it is at fault, which, with proper maintenance, is rare.

Figure 13 shows the coiler motor with a separate generator to supply power. Normal economies and practice would prove this to be a good selection. The coiler motor could be supplied from the main mill motor generator. However a booster generator would be required since the main generator does not have a voltage proportional to strip speed, because the main mill motors (referring to Table I) all have considerable speed range by field control. This booster would necessarily be quite large for several reasons. First, a field range in the main motor of 2 to 1 would require the booster to be at least one-half the voltage of the main generator even if the coiler motor is designed to operate at the same voltage as the main motor. If the coiler motor, as is quite likely, has a lower voltage rating than the main motor, the booster would need to be still larger. Second, if a high thread speed is used, as is desirable, the main generator could be almost up to full voltage when the coiler is still at rest. To oppose this voltage in starting the coiler from zero speed then would require almost a full voltage booster. Because of these reasons and the additional complexity to the control it is doubtful if anything other than a separate generator for the coiler should even be considered.

Figure 15 is a recent record of the performance of a typical coiler. These recording charts show the armature current-motor speed relationship on a 600-hp coiler motor during a typical schedule.

PINCH ROLL

The pinch rolls have one main function on most of these mills, and that is to pull the strip off the furnace coiler and start it into the mill again. When that function is completed, the sooner they can be raised off the strip the better; so most operators say. To raise these pinch rolls automatically at that time would be desirable but no clean cut solution seems to be at hand. Many operators raise these pinch rolls with a foot operated pushbutton or if they do not, they are raised automatically when the opposite coiler starts.

The selection of a motor for the pinch rolls depends somewhat on the mill design. In Table I all spaces are not filled in because of lack of information but it can be seen from those which are filled in that the early mills provided the same size motor on the pinch roll as was used on the furnace coiler, which at first glance seems reasonable. On later mills however, the reasoning must have gone something like this: (1) The pinch roll duty cycle is so intermittent that it can easily work at two or three times rated torque when in operation; (2) if the mechanical design is such that this pinch roll motor does not have to run at strip speed after it is raised, it could be geared in for a lower top speed than the rest of the mill; and (3) the back tension of the furnace coiler could be at least temporarily reduced until the pinch rolls work is done.

Whatever the reasoning process, the trend appears

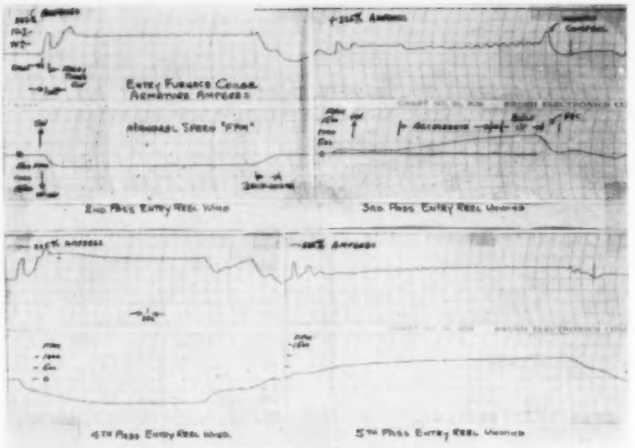


Figure 15 — Recording charts show the performance of a 600-hp furnace coiler drive on a recent installation.

to be toward less "pull per inch width" as can be seen in mill No. 13. Here the 150-hp pinch roll motor pulls at 200 per cent amperes and the 600-hp furnace coiler pulls back at less than 50 per cent rated amperes. The design is such that the top roll is in contact with the strip at all speeds, and therefore is geared to run at top motor speed at top mill speed. This appears to be a good practical compromise and has plenty of pull.

The practice is to supply the standard mill auxiliary type motor for this service. It is good practice to furnish this motor with clean air from the motor room to take advantage of its forced ventilated rating.

The control is a standard rotating regulator, adjustable voltage auxiliary type, except the anti-plugging features need not be supplied since these motors never accelerate or decelerate any faster than the mill. The pinch roll is normally supplied by a separate generator. The generator voltage is regulated to be proportional to mill speed. Since the pinch roll has practically no load at high speed, it tends to synchronize as accurately as if it were tied by a speed regulator on the winding side. On the unwinding side, again as in the case with the coiler, draft compensation is approximated by a fixed adjustment; therefore the pinch roll may tend to motor or generate slightly if this approximation is not a good one. Usually a current limit feature is incorporated into the voltage regulator to prevent exceeding the commutating limits of the machines.

A problem which must always be settled with each mill concerns automatic or manual operation of the lift and pinch motions on the pinch rolls. There are various practices most of which could be made automatic if they could be defined. One common sequence is the following:

1. Mill stopped — both left and right pinch rolls "pinch."
2. Mill rolls from right to left — left pinch roll to "high lift" — right pinch rolls remain at "pinch."
3. Strip being pulled from right furnace coiler enters mill — right pinch roll raises to "low lift" — left pinch roll remains at "high lift."
4. Strip enters left coiler — coiler starts and left pinch roll drops to "low lift" — right pinch roll remains at "low lift."
5. Mill stops — both pinch rolls "pinch."
6. Mill rolls from left to right and the reverse sequence to the above occurs.

Sometimes the above sequence is varied because the layout is such that the mill and tables can not push the strip the entire distance from the mill, through the pinch roll, up the deflector gate, and into the slot without buckling. If this exists, special mechanical guides are built to guide the strip into the pinch rolls receiving strip from the mill even though the end is turned up. This alters the above sequence only slightly, but must be known before the control is designed as some of these automatic sequencing layouts are not easy to change once built and shipped.

TABLE ROLLS

As shown in Figure 1 approximately six small table rolls are normally located on each side of the mill. These rolls should be driven individually by runout table motors, similar to those used on the runout tables of hot strip mills. If so, they can be supplied by the same generators as the pinch rolls. They are generally direct connected and are rated slightly higher in horsepower than the runout tables to allow for the heavier passes. The 4-hp appears to be a popular size for mills from 42 to 72 in. wide and with speed from 1200 to 2000 fpm.

Another roll located near the entrance of the coiler furnace above the strip serves as a point to bend the strip on coilers which run against the strip. This so-called "breaker roll" is supposed to be of advantage in eliminating secondary scale. This roll is normally driven by a motor, a duplicate of those on the table and generally is supplied by the same generator. These rolls, even though water cooled, can not keep their shape if they are stopped for long periods because of the extreme heat from the furnace. On some controls if this condition exists, an automatic timer has been incorporated to start these "hot rolls" any time the mill is down for more than a preset time unless they are selected "off" by the operator.

The most important thing about the rollers is that they be adjusted to always run at such speed in respect to the mill and pinch rolls that they do not allow the strip to "hump." This will cause a "cobble" faster than almost anything else. Some mills have used constant potential d-c motor drives for these rolls, and another mill used a-c motor drives with a 25, 50 and 75-cycle frequency supply switched in the proper sequence. Constant potential drives should be discouraged.

SIDE GUIDES

The mechanical design of the side guides is very important. If there are any edges or crevices where a recalcitrant strip can go under, through, or around, it will and a cobble will result every time. Most installations have spent considerable time modifying their side guides, both mechanically and electrically. One practice has been to supply a constant potential d-c adjustment motor complete with brake, a selsyn transmitter, an extreme travel cam limit switch, a special "short stroke" limit switch complete with clutch for disconnecting it and a brake for holding it when declutched.

The object of this array of equipment was to:

1. Adjust the guides to the proper opening to just clear the strip to be rolled with the extreme travel limit switch to prevent a careless operator from jamming them mechanically.
2. With this condition set, closing the clutch of the short stroke limit, switch and releasing the brake allows any operation of either a manual or automatic nature to open the guides by a few inches or close them to the original position.

The drawback with this system was that it needed both more speed and more accuracy for the short stroke operation. If the electric motor had high speed, it was not accurate, and if accurate, was too slow. To achieve at minimum cost both accuracy and high speed, it is suggested that the short stroke equipment should be pneumatic or hydraulic. Several systems have been converted to this and are performing much better than the electric systems.

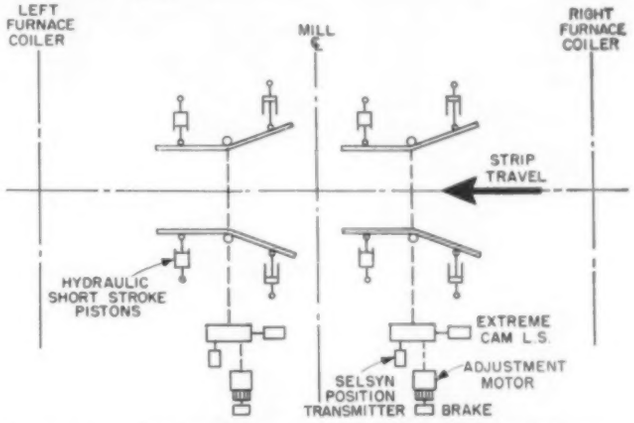


Figure 16 — Sketch shows one method of side guide operation. All short stroke solenoids operate when mill reverses.

Automatic operation of the side guides can easily be obtained except here again the practice must be defined and there is a wide difference in practices. One practice is as follows:

1. Right pinch roll feeds strip from right furnace coiler — right sideguide open on right end — closed on left end (see Figure 16 for sketch of side guide).
2. Mill feeds strip toward left furnace coiler — left sideguide open on right end, closed on left end.
3. When mill reverses, both sideguides reverse i.e. left sideguide opens on left end and closes on right end, while right sideguide opens on left end and closes on right end. In other words, the theory is the strip always enters the sideguide at the open end and leaves at the closed end. This operation can easily be made automatic by tying in the short stroke solenoids with the mill direction relays.

SCREWDOWNS

The screwdowns on a reversing hot strip mill are worthy of special thought for a few minutes, because of the wide range of requirements. On the reversing slabbing and roughing mill, the screws must be as fast as those of a blooming mill, yet as accurate as those on a plate mill. Notice in the typical schedule shown in Table II that on occasions roll opening changes of nearly 30 inches must be made between passes. To handle such changes screw speeds of about 500 in. per min should be used. Yet notice on some passes, changes as small as

TABLE II

Typical Rolling Schedule for a Combination Reversing Slabbing and Strip Plate Mill Ingot Data, 26 x 47 x 66 in. Weight 19,600 lb Temp 2200 F

Pass No.	Opening, in.	Width, in.	Roll diam, in.
0	47	26	37.75
1	44.68	26	37.75
2	43.06	26	37.75
3	24.54	43.06	37.75
4	23.13	43.06	37.75
5	42.34	23.13	37.75
6	40.46	23.13	37.75
7	22.12	40.46	37.75
8	20.40	40.46	37.75
9	18.87	40.46	37.75
10	17.49	40.46	37.75
11	15.96	40.46	37.75
12	15.09	40.46	37.75
13	12.99	40.46	37.75
14	11.71	40.46	37.75
15	41.99	11.71	32.75
16	38.24	11.71	32.75
17	11.87	38.24	37.75
18	11.23	38.24	37.75
19	36.71	11.23	32.75
20	34.40	11.23	32.75
21	10.37	34.40	37.75
22	8.78	34.40	37.75
23	7.03	34.40	37.75
24	5.57	34.40	37.75
25	34.09	5.57	32.75
26	32.78	5.57	32.75
27	4.73	32.78	37.75
28	3.68	32.78	37.75
29	32.68	3.68	32.75
30	31.99	3.68	32.75
31	2.62	31.99	37.75
32	2.62	31.99	37.75
33	2.62	31.99	37.75
34	1.84	31.99	37.75
35	1.56	31.99	37.75
36	0.84	32.13	37.75
37	0.65	32.13	37.75

Notes:

1. **Slab cropped after pass 33.**
2. **Pass 31 and 32 flattening front end.**
3. **Pass 33 full pass.**
4. **Edger used on pass 36.**

0.2 in. were required. For these small changes the control must be switched to a low speed of about 10 in. per min. This requires that some special thought be given to the electric equipment to cover this 50 to 1 range in speed and still have full torque available for screwing down into the metal if necessary. If, as is general practice, one motor is geared to each screw and coupled to each other by a clutch, the only feasible method of controlling such screws is by the use of an adjustable voltage system suitable for operating up to double voltage on the high speeds and down to almost IR voltage on the lower speeds.

On the reversing hot strip finishing mill, on the other hand, the range of screw position changes may not be any greater, but an additional complication is that the screws must continually be leveled by amounts as small as 0.0005 in., yet must quickly open from 0.050 to 1.00 in. or more to receive a new slab. The top speeds on these mills for the screws are about equal to the slowest speeds for the rougher or 10 in. per min. The slowest speeds, which are needed for leveling, should be in the neighborhood of 0.2 in. per min. This range of speeds has been covered by various methods on the finishing mill.

Refer to Figure 17 for several mechanical one line diagrams for typical screwdown arrangements.

Method No. 1 uses one motor to each screw and has the two motors clutched together (preferably on the high speed shaft) by a serrated face clutch. With such an arrangement the only possible way to cover such a wide range of requirements would be to use a rotating regulator controlled adjustable voltage system and even here special consideration must be given to obtain a 50 to 1 range in speeds.

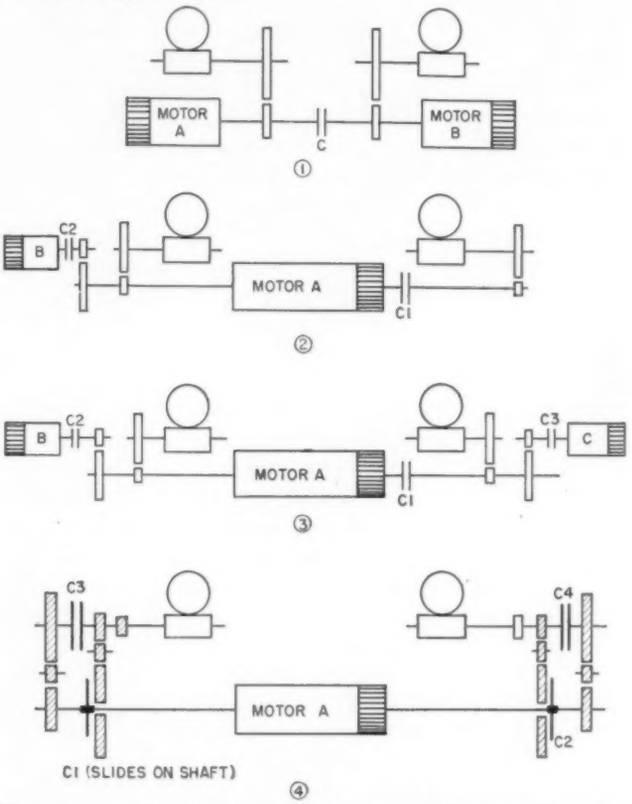


Figure 17 — Sketch shows various screwdown mechanical arrangements for reversing hot strip finishing mills.

Method II uses a large motor A which drives both screws at high speed when clutch C_1 is closed and clutch C_2 is open. A smaller motor B can drive both screws through an additional gear reduction at a slow speed if both clutch C_1 and C_2 are closed or can level on one screw only if clutch C_1 is open and C_2 is closed.

Method III improves on method II in that one more motor clutch and gear is provided so that the operator can level with either screw. To drive both screws down at a slow speed both motors B and C can be operated in parallel with clutches C_1, C_2 and C_3 closed.

Method IV is the most economical on motors but has the most clutches. Here one motor drives through clutches C_1 and C_2 for high speed on both screws, or through clutches C_3 and C_4 for slow speed on both screws. Slow speed leveling of course if C_3 or C_4 only is engaged.

Methods II, III and IV can all use standard constant potential motors and controls, standard that is except the controls must have numerous interlocking and timing relays to prevent the wrong motors and clutches from getting together no matter what combinations of remote master switches are operated.

Screwdown horsepower selection is at best a calculated risk depending on gear efficiencies and screw friction in addition to screwing into hot and not so hot metal of various thicknesses. However, by observation of the horsepower supplied on various mills it is possible to say 2.5 hp per in. mill width per ipm of screw travel per screw is about maximum, ½ hp is minimum and 1.4 hp is average.

Automatic screwdown has been supplied on some mills. Automatic screwdown has the same arguments pro and con here as it does on any mill. If the orders are repetitive, the operator will take the time to set up the schedule on the automatic screwdown. If not it will remain unused. The automatic screwdown has a more difficult time on this application than on many because of the wide range of adjustments required. It must be both fast and accurate. Operators will neither wait for a slow screwdown nor tolerate a fast but inaccurate one.

RUNOUT TABLES, FLYING SHEARS AND END COILERS

These auxiliaries have been covered in previous articles on continuous hot strip mills and there is little else to be said about them for a mill of this type. The runout tables are generally in three sections, sometimes less, where four sections are common for continuous mills. The flying shear, a rarity on these mills, must cut to length as the mill is accelerating and must continue to cut to length after the strip has left the mill and is no longer under its control. Little has been done about refining the continuous strip mill flying shear control. The main point is that this condition should be recognized and the same high accuracies normally attained should not be expected.

The end coiler has the same problems as all end coilers except here too the coiler is quite often called upon to change speed with the mill as evidenced by the charts in Figures 7, 8 and 9. This means that an inertia compensation signal should be supplied probably from a mill pilot generator to the end coiler tension regulator.

TABLE III

Typical Schedules for a Reversing Hot Strip Finishing Mill

Pass No.	Leave, in.	Per cent draft	Width, in.
No. 1			
0	0.60	—	41.5
1	0.315	47.5	41.5
2	0.178	43.5	41.5
3	0.111	37.6	41.5
4	0.087	21.6	41.5
5	0.079	9.2	41.5
No. 2			
0	0.60	—	41.5
1	0.323	45.2	41.5
2	0.197	39.0	41.5
3	0.126	36.0	41.5
4	0.107	15.1	41.5
5	0.079	7.5	41.5

TABLE IV

Pulpit Layout

Head Roller (Left Desk)

Mill tachometer
Mill ammeter
Left coiler ammeter
Screwdown master switch "Fast"
Screwdown master switch "Slow"
Screwdown master switch "Level"
Left table and pinch roll selector "Auto-Off-Jog"
Left side guide selector "Auto-Manual"
Left side guide master "In-Off-Out"
Mill slow pushbutton
Mill stop pushbutton
Left pinch roll selector "Auto-Down-Off-Up"
Left coiler selector "Auto-Off-Jog-Run"
Left side guide position indicator
Left side of mill flat pass selector "Coil-Flat Pass"
Set of screwdown indicators
Left coiler wrap counter
Top mill speed selector
Approach table selector

Assistant Roller (Right Desk)

Mill tachometer
Right coiler ammeter
Mill master switch
Mill jog switch
Right table and pinch roll selector "On-Off-Jog"
Right side guide selector "Auto-Manual"
Right side guide master "In-Off-Out"
Mill slow pushbutton
Mill stop pushbutton
Right pinch roll selector "Down-Off-Up"
Right coiler selector "Auto-Off-Jog-Run"
Right side guide position indicator
Right side of mill flat pass selector "Coil-Flat-Pass"
Main mill circuit breaker "Open-Close"
Foot switch for water sprays
Right coiler wrap counter

Another refinement occasionally requested is an automatic speed tie between the mill and the end coiler. This automatic speed tie relieves the end coiler operator's problems considerably since he no longer must worry about what the speed of the final pass may be. Particularly is this true if the mill changes speed during the coil, a condition rarely encountered on a continuous finishing mill.

The disadvantage of a normal speed tie is that the mill must continue to run until the strip is completely coiled. This disadvantage can be overcome by providing the mill speed reference with a "memory" device which will remember where the finishing mill was running before it shut down. This memory device could be reset when the end coiler is stopped.

PULPIT ARRANGEMENTS

In Table I there are listed 13 mills now in operation. These 13 mills all have a different pulpit arrangement. They vary from a minimum of one pulpit containing two men to a maximum of three pulpits and four men. The trend appears to be toward two pulpits and two men. The biggest reason for this trend is that the operators must be able to see the strip clearly and quickly on each side of the mill; particularly if anything goes wrong. This makes a central pulpit of little use. The best way appears to be to locate one pulpit on each side of the mill at an angle. These pulpits must be far enough back to get away from the furnace heat, but

close enough and high enough that the operators can see over the side guides and watch the strip during threading to see if it clears the guides, during running to see if the mill is level, and during stopping to see that the strip end stops between the mill and the pinch roll on the winding side.

Considerable headaches and possible expense can be avoided if in the early stages the pulpits are designed and installed such that they may be moved a reasonable amount higher or lower, left or right, and up or back, to suit the operator.

With a two desk philosophy it becomes hard to tell the head roller from the assistant roller unless we define the head roller as the man who adjusts the screws and selects the top operating speed. The assistant roller from the other desk can start the mill in the proper direction. Some rollers would like to have a mill master switch on each desk so that either operator can have control of the mill. This is particularly desirable when the mill is new and cobbles are quite common. However, once in full production, control of the main mill from both desks is not used or needed. Some thought could be given to supplying a second mill master switch and a selector, but it is doubtful whether the additional complication could be justified in the long run. It is necessary that either operator be able to slow down the mill when the coiler on his side shows only a few wraps; and to stop the mill when the strip has disappeared through the main mill rolls. Most other functions of the two desks are connected with the auxiliaries located on that side of the mill.

A typical (hypothetical) pulpit layout might be as shown in Table IV.

AUTOMATIC VS MANUAL OPERATION

The control of a reversing hot strip finishing mill is very simple if automatic sequencing and protective interlocking against false operation are omitted. If each auxiliary discussed starts-stops, pinches-raises, opens-closes or raises-lowers only when an operator closes a switch, there would be some very busy operators or maybe several more, but the control would be flexible — anything could happen in any sequence. But once it has been decided to eliminate some of the operators' work and possibly even some of the operators, it is necessary that the sequence of operations be decided upon and adhered to or the expedient revisions made on the spot in the automatic control can become so confusing that even the designers can not predict what should happen. Two mills located in a foreign country within miles of one another are as unlike as two mills can possibly be. One is completely automatic — the other completely manual. The automatic mill has two operators, the manual either three or four. The reason given for the all manual mill is "extra operators are still cheaper than good electricians — when that becomes no longer true we will make our mill automatic."

GAGING EQUIPMENT

Reversing hot strip mills are not as well equipped with gages as are the bigger continuous and semi-continuous mills. Only three mills as yet are known to have installed non-contacting hot strip gages. One of these is located in the United States, one located in Canada and one in Luxembourg. All three are now using the conventional hot strip mill x-ray gage where the strip thickness is measured by x-rays which in turn are generated by a high voltage x-ray tube. The Canadian mill originally installed a gage which utilized the radiation of a radioactive source.

It is hard to see how any hot strip mill can justify not having a continuous reading thickness gage. It does not take much "off gage" material to pay for such an equipment. To expect a man to roll "on gage" material without a continuous thickness indication is as practical as expecting a man to drive an automobile at an exact speed without a speedometer.

Figure 18 — View of motor room for a 66-in., 4-high reversing hot strip mill shows the adjustable voltage auxiliary motor-generator set in the foreground, its associated control immediately behind, and the 5000-hp, 70/170 rpm main drive motor in the background.

MOTOR ROOM LAYOUTS

There is nothing unusual about the motor room layouts. The same problems are encountered as are found in all hot strip mills. They are all located in a very dirty atmosphere and must be careful where they get ventilation air. One reversing hot strip installation in Canada helped solve this problem by installing a fume exhaust system over the mill which collects all this red iron oxide. This oxide is sold to cosmetic manufacturers for more than enough to pay for the cost of collecting it. It would certainly improve the atmosphere for the electrical equipment if more installations were to try such a system.

Figure 18 shows a typical motor room layout with the adjustable voltage auxiliary motor generator sets in the foreground, the control for these auxiliaries immediately behind them, and the main drive equipment in the background.

SUMMARY

Reversing hot strip mills are still relatively new and the practices and requirements have not as yet been definitely established. As more experience is gained in the operation of these mills, the easier it will be for the operators, mill builders and electrical suppliers to determine in advance exactly what is required to do the best job. With these requirements known the electrical de-

sign, analytical, and application engineers will be able to design refinements into the electrical equipments which will make this mill simple, flexible, reliable and yet completely automatic. With the great increase in recent years in both methods and experience in analyzing regulating systems, and the development of such aids as the electronic differential analyzer which make such work practical, the electrical application engineer can, given the facts, along with the design engineer and the analytical engineer, design a system to do almost anything that can be desired. Therefore, if the conditions can be defined there is no reason why a mill of this type can not be the most automatic foolproof piece of equipment in the steel industry.

TENTATIVE PROGRAM

ASSOCIATION OF IRON AND STEEL ENGINEERS

WESTERN MEETING

HOTEL STATLER

LOS ANGELES, CALIFORNIA

February 20, 21, 22, 1956

Monday, February 20

8:30 am — Registration

9:00 am — Technical Session — Sierra Room

"Developments in Scalebreaking and Continuous Pickling Lines," by J. I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"Pipe Mill, Utah," by M. P. Klick, Chief Engineer, Consolidated Western Steel Div., United States Steel Corp., Los Angeles, Calif.

"Discussion of Gear Tooth Forms For Steel Mills," by John J. Stolz, Assistant Vice President Engineering, Tool Steel Gear and Pinion Co., Cincinnati, Ohio.

2:00 pm — Technical Session — Sierra Room

"A Symposium on Continuous Annealing Lines,"

Speakers From: Drever Co.
Wean Engineering Co., Inc.
Westinghouse Elect ic Corp.
Cutler-Hammer, Inc.

Tuesday, February 21

9:00 am — Technical Session — Sierra Room

"Recent Developments in Sintering and Pelletizing," by Edwin N. Hower, Manager, and John A. Anthes, Process Engineer, Industrial Dept., Dravo Corp. Pittsbu gh, Pa.

"Some Methods for Analyzing and Controlling an Open Hearth Operation" by Eugene H. Swett, Fuel Engineer, Bethlehem Pacific Coast Steel Corp., South San Francisco, Calif.

"Design and Construction of Fontana Open Hearth Precipitators," by E. V. Akerlow, Project Engineer, Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

"Method of Testing Open Hearth Precipitations," by J. H. Smith, Engineer, Kaiser Steel Corp., Fontana, Calif.

2:00 pm — Technical Session — Sierra Room

"Electrical Maintenance, Pueblo Plant of the Colorado Fuel and Iron Corp.," by Harold E. Watson, Electrical Superintendent, Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

"Tonnage Heating by Induction," by R. S. Segsworth, Director of Research, The General Engineering Co., Ltd., Toronto, Canada, an M. C. D. Hobbs, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada.

"Electric Drive Systems for Rod, Bar and Merchant Mills," by F. E. Fairman, III, Steel Mill Application E gineer, General Electric Co., Schenectady, N. Y., and A. C. Parsons, Steel Mill Engineering, General Electric Co., San Francisco, Calif.

7:00 pm — Dinner — Pacific Ball Room

Wednesday, February 22

Inspection Trip to Los Angeles Plant, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

HOTEL RESERVATIONS

Write direct for hotel reservations to Hotel Statler, Los Angeles, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for AISE Western Meeting.

Effect of Changes in Gas Composition on the Utilization of Fuel Gases

By E. X. SCHMIDT

Development Supervisor, Cutler-Hammer, Inc., Milwaukee, Wisc.

. . . . this paper gives a number of curves which can be used to determine the suitability of substituting one type of fuel gas for another . . . . information is valuable in selection of burner adjustments . . . .

▲ THE effects of changes in gas composition on the utilization of fuel gases in the steel mill, is a subject about which a quarter century ago we thought we knew a great deal. In fact, at that time we designed and built a gas stabilizing control for the fuel gas supply for a steel mill. This control modified a fuel gas supply of widely varying combustion characteristics by controlling the admixture of air to produce a final fuel gas supply with a constant air requirement factor. The control was operated satisfactorily during the many years when large variations in fuel gas supplies made stabilization desirable.

Our practical experience with the varied and special problems encountered in the utilization of fuel gases in the mill is limited. During the past 25 years we have found some things which will be of value in connection with a great many combustion problems associated with changes in gas composition. It is our hope that our method of presenting information on the combustion characteristics will help in a better understanding of combustion behavior.

During the past quarter century a great deal of effort has been expended in the study of gas interchangeability, particularly in relation to use of commercial gases on domestic appliances. Gas which can be substituted on domestic appliances without causing serious customer complaints in respect to flash-back, lifting, incomplete combustion, and objectionable luminosity are classified as interchangeable.

Both the definition and the subject of gas interchangeability are controversial. A great deal of valuable information is available on the subject in the published papers of the American Gas Association, the National Bureau of Standards and the Bureau of Mines. Other independent workers have also expended considerable effort on the subject of interchangeability. Although much of this information is not directly applicable to industrial applications of fuel gases, it is frequently of value by inference.

In this paper we will present gas interchangeability data in a slightly unconventional manner, which we believe is useful in the practical application of available information.

In the accumulation of these data, procedures have been used which are controversial, but the predictions based on the data appear to agree rather well with factual test data. We will not attempt to justify our procedures in calculating combustion data for composite fuel gases since it would require a great deal of time and continue to be controversial. At this time we should like to explain that in determining some of the combustion characteristics of a composite gas, in particular the flame velocity characteristic as a function of per cent primary air, we assume the characteristic of the composite gas is related to the summation of products of the characteristic and the decimal part of the total therms contributed by each component simple gas. Although this assumption is controversial, it gives substantially the same answer as the Paymen method and the Bureau of Standards methods of Mr. Weaver for calculating those flame velocities for which these latter methods are applicable. The flame velocity data calculated by our procedure also agree reasonably well with factual test data, where such data is available for composite gases. The usefulness of our assumption in calculating flame velocity data may be apparent. Since this assumption appears factual, it is also useful in calculating effects of partial substitution of peak shaving operations for fuel gas supplies. Admittedly, there are some weaknesses in our procedures in calculating data. Our data will, in general, be presented as a function of type of gas and total heating value. We all know that the composition of gases may differ due to differences in manufacturing procedure and that gas analysis for the same gas will differ with different methods of analysis. Unsaturated hydrocarbons are seldom broken down by composition in the gas analysis. Satisfactory flame velocity data for some of the unsaturated hydrocarbons

are not available. It is therefore suggested that the reader assumes that our combustion data is factual, and we believe that it will be found sufficiently accurate for most combustion calculations.

One other fact may be mentioned at this time. In our data, we assume that flame velocity and its effect on flame behavior is unaffected by burner port size, shape and other mechanical details of burner construction. Obviously, this assumption is not correct. Flame velocity is affected by numerous factors besides gas composition and per cent primary air. Fortunately, it appears that relative flame velocity is substantially unaffected by burner port size except in the very small burner port sizes. In our calculations of flash-back behavior, we prefer to express flame velocity in distance per second and burner port velocity in the same terms and retain these units in determining rates of heat input per unit port area. The flash-back data in the units used in the data then apply only to a given burner size and can not be used quantitatively, in burner design or use but should be used only in calculating relative behavior on the same burner.

We might also mention that the application of lifting data to industrial application of fuel gas should be done cautiously. The lifting phenomena is not readily adaptable to theoretical analysis. Undoubtedly, lifting is appreciably affected by mechanical details of burner parts and combustion chamber construction. Thus, the influx of secondary air or inerts affects lifting. The simple but strange relation of primary air in the burner port and the lifting phenomena determined by the A.G.A. for simple gases, a relation which is in reasonably good agreement with Bureau of Mines findings, is useful. Its usefulness is somewhat questionable, in that its validity is supposed to be limited to rates of heat input of 10,000 to 100,000 Btu per hour per square inch of port area. It might also be noted that Mr. E. R. Weaver of the National Bureau of Standards in his presentation of statistical data demonstrates that relative lifting behavior is more nearly a function of maximum flame velocity rather than to flame velocity at 100 per cent primary air. The latter relation is assumed by the A.G.A. for simple gases. For composite gases, the A.G.A. assumes a complicated relation involving density and flame velocity at 100 per cent primary air of the component constituents.

In our lifting calculations we base our data on the A.G.A. procedure for simple gases and use the same procedure for composite gases, that is, our lifting calculations are based on flame velocity at 100 per cent primary air.

Although the similarity of the Weaver procedure and our procedure is somewhat obscure, conclusions in respect to relative lifting behavior compare rather well particularly for gases with flame velocities for which the procedures are assumed to be valid, namely for gases with flame velocities which by our method, give rates of heat input for lifting of 10 to 100,000 Btu per hour per square inch of port area.

Although relative lifting calculations agree rather well, the Weaver method does not lend itself to calculation of lifting behavior in terms of rate of heat input as a function of burner adjustment. We consider this relation of some value in the study of combustion behavior. In this connection it is interesting to note that in accordance with the A.G.A. procedure and our procedure, an increment of 10 per cent in per cent primary air value decreases the rate of heat input for lifting by a factor of 0.69. This rather surprising effect, which is assumed to be the same for all air free gases, appears to be in fair agreement with test data of the A.G.A., Bureau of Standards, and Bureau of Mines.

PROPERTIES OF GAS AFFECTING COMBUSTION

In the utilization of fuel gas the most important property of the gas is the air requirement factor. We prefer defining this as $(aH/\sqrt{d})$, where "a" is the theoretical air requirement per unit of heat, "H" is the heating value per unit volume and "d" is the density.

The importance of this air requirement factor justifies further discussion. On practically all fuel gas applications, including induced air burners, the rate of combustion air supply and the split in primary and secondary combustion air supply is substantially unaffected by changes in gas composition. The volumetric rate of gas supply varies inversely as the square root of the density. The rate of heat input is equal to the product of rate of gas supply and heating value, and the theoretical air requirement of the flowing gas is equal to the product of heat input and air required per unit of heat.

Defining combustion air supply in terms of per cent of the theoretical air required for complete combustion, the per cent combustion air is inversely affected by the air requirement factor of the gas $(aH/\sqrt{d})$. Thus combustion air, both primary and total on gas burning equipment operated on a gas with an air requirement factor of $(aH/\sqrt{d})_B$ is directly affected by factor $\frac{(aH/\sqrt{d})_B}{(aH/\sqrt{d})_S}$ where $(aH\sqrt{d})_S$ is the air requirement factor of the substitute gas.

Similarly relative rate of heat input is directly affected by the ratio of heat input factors, $\frac{(H/\sqrt{d})_S}{(H/\sqrt{d})_B}$. In general this is less important than the inverse ratio of air requirement factors.

Per cent total combustion air is important for maintenance of furnace atmospheres, and combustion efficiency. Per cent primary air combined with combustion characteristics of the gas determines flame behavior.

It might be noted that burner port velocity is affected only by the change in rate of gas flow, the rate of primary air flow being unaffected by changes in gas composition. The change in port velocity due to changes in gas density is therefore relatively small particularly with high heating value gases and high primary air values, a condition frequently encountered in natural gas application. If we should then establish the primary air values P which produce the same flame velocity on two different gases, flame behavior in respect to flash and inner cone size would be similar on both gases. As an example if $(P)_B$ and $(P)_S$ for gas B and gas S respectively are required to produce the same flame velocity, maintaining the product $(P)_B\ (aH/\sqrt{d})_B$ equal to the product $(P)_S\ (aH/\sqrt{d})_S$ would tend to maintain flame

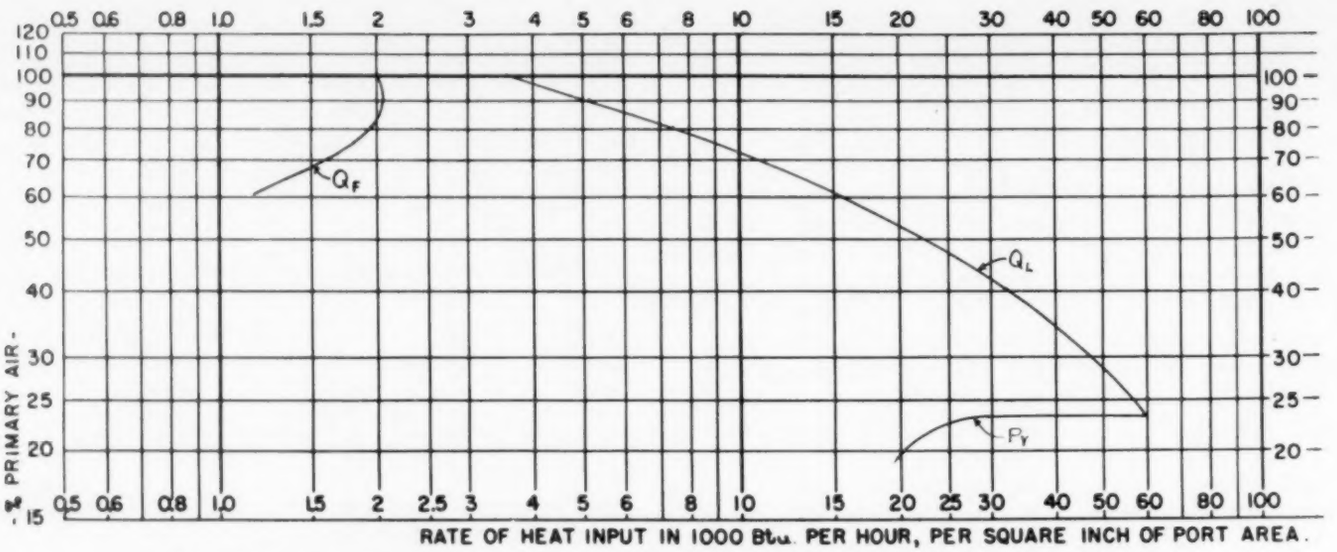


Figure 1 — Combustion data is given for natural gas with a Btu content from 1000 to 1050.

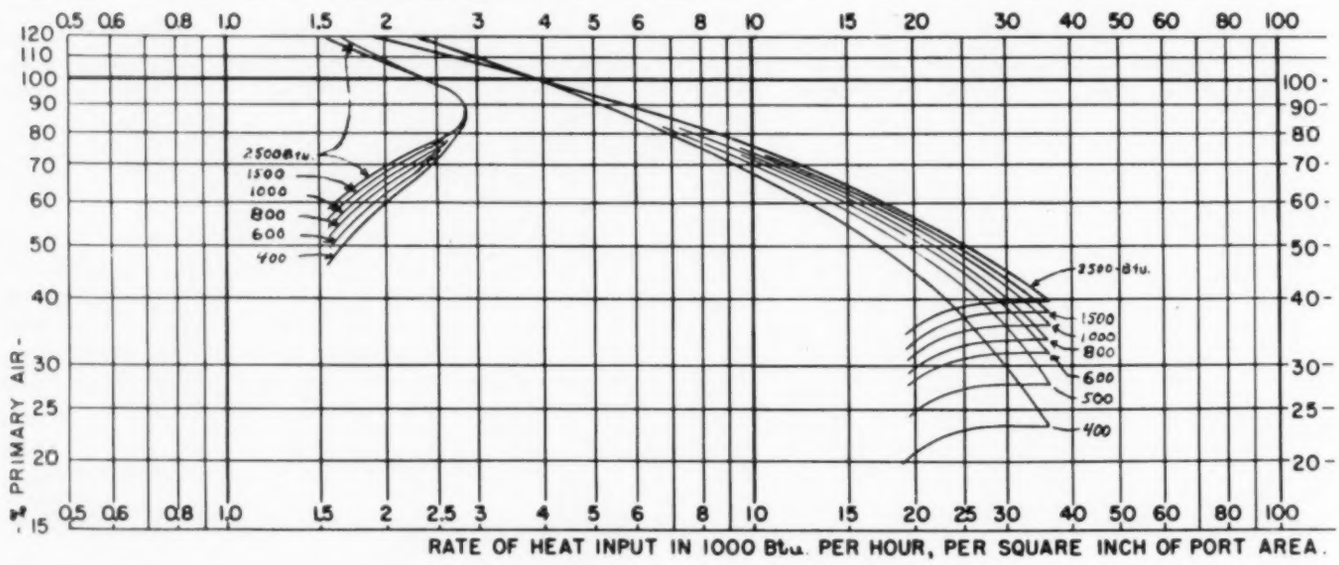
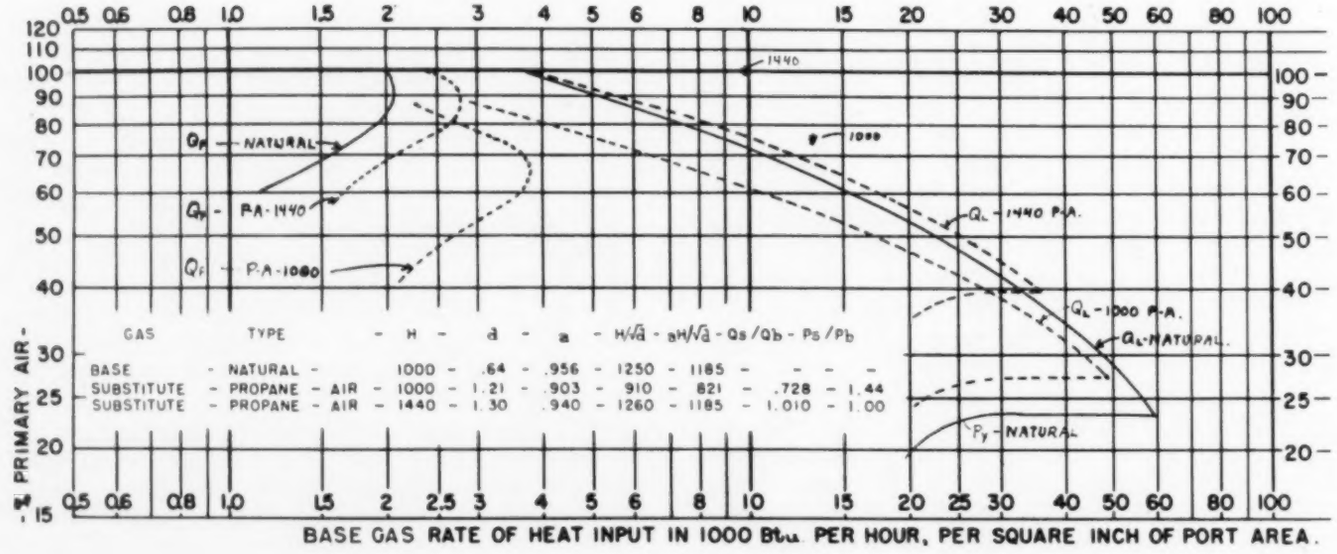


Figure 2 — Combustion data is given for propane-air gas.

Figure 3 — Chart gives effect of substituting propane-air for natural gas.


% PRIMARY AIR
Q_F — NATURAL
Q_F - P-A-1440
Q_F - P-A-1000
1440
1000
Q_L - 1440 P-A.
Q_L - 1000 P-A.
Q_L - NATURAL
P_Y - NATURAL
GAS TYPE - H - d - a - $H/\sqrt{a}$ - $aH/\sqrt{a}$ - Qs/Qb - Ps/Pb
BASE - NATURAL - 1000 - .64 - .956 - 1250 - 1185 - - - -
SUBSTITUTE - PROPANE - AIR - 1000 - 1.21 - .903 - 910 - 821 - .728 - 1.44
SUBSTITUTE - PROPANE - AIR - 1440 - 1.30 - .940 - 1260 - 1185 - 1.010 - 1.00
BASE GAS RATE OF HEAT INPUT IN 1000 Btu. PER HOUR, PER SQUARE INCH OF PORT AREA.

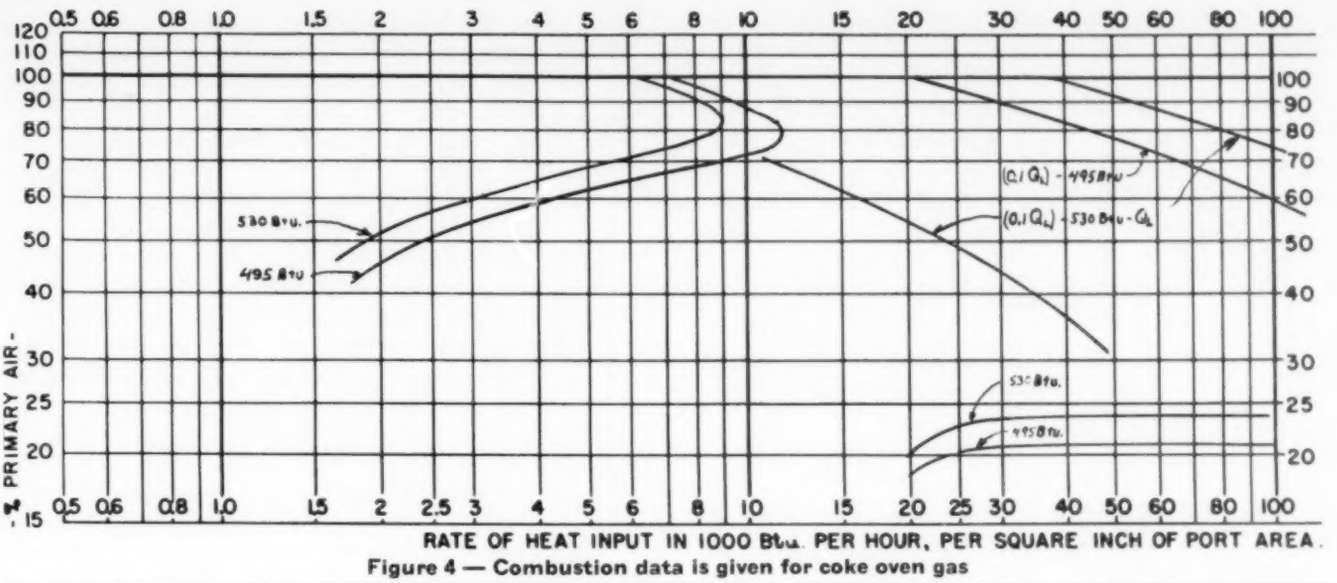
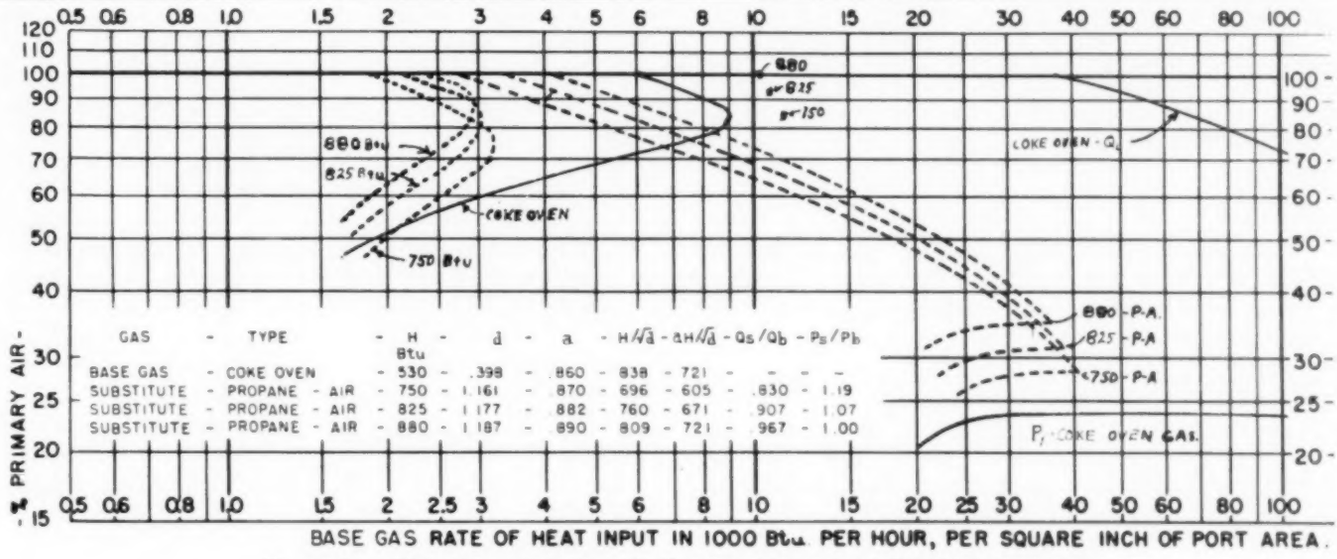


Figure 4 — Combustion data is given for coke oven gas


0.5 0.6 0.8 1.0 1.5 2 3 4 5 6 8 10 15 20 30 40 50 60 80 100
120 110 100 90 80 70 60 50 40 30 25 20 15
% PRIMARY AIR
880
825
750
880 Btu
825 Btu
COKE OVEN
750 Btu
COKE OVEN - Q_L
880 - P.A.
825 - P.A.
750 - P.A.
P_Y - COKE OVEN GAS.
BASE GAS RATE OF HEAT INPUT IN 1000 Btu. PER HOUR, PER SQUARE INCH OF PORT AREA.

GAS - TYPE	H - Btu	d	a	H/√a	ΔH/√a	Qs/Qb	Ps/Pb
BASE GAS - COKE OVEN	530	.398	.860	838	721	-	-
SUBSTITUTE - PROPANE - AIR	750	1.161	.870	696	605	.830	1.19
SUBSTITUTE - PROPANE - AIR	825	1.177	.882	760	671	.907	1.07
SUBSTITUTE - PROPANE - AIR	880	1.187	.890	809	721	.967	1.00

Figure 5 — Chart gives data on substituting propane-air for coke oven gas.

velocity, inner cone size, and flash back tendency similar. Thus the factor (P_s) $(aH/\sqrt{d})$ might be considered a useful factor for the gas related to flash back, where P_s is the primary air adjustment for producing a flame velocity equal to 8 per cent of the maximum flame velocity for hydrogen, a velocity which can be established for any gas air mixture. The usefulness of this factor is limited for several reasons. With wide differences in P_s value, the ratio of primary air values (P) for producing the same flame velocity differ for different flame velocities. Furthermore with low heating value gases and low primary air values, port velocities may differ measurably so that establishing the same flame velocity will not necessarily produce the same flash back tendency. It is of interest to note that with gases of differing flame velocities, in order to maintain similar flame velocity it is necessary to have differing air requirement factor and the associated differences in per cent combustion air.

For a more complete analysis of flame behavior, a different method of attack is necessary, involving not only gas characteristics, but also burner adjustments in respect to rate of heat input and primary air adjustments. The analysis lends itself best to graphic solution.

Combustion characteristics for any gas in respect to flash back, lifting and luminosity can be presented in graphic form as a function of rate of heat input per unit port area, and per cent primary air. Figure 1 is representative of graphic data of this type for natural gas. Note that both scales are logarithmic. The reason for the use of logarithmic scales will be apparent subsequently. Flash back and lifting will occur in the area of the chart to the left of the flash back curve Q_F and to the right of the lifting curve Q_L respectively. A degree of luminosity in excess of that considered objectionable on domestic appliances will occur in the area below the "P_Y" curve. Although the mill engineer may not be interested in this unit of luminosity, the "P_Y" curve gives some indication of relative flame luminosity, or the relative value of primary air which will produce the same degree of luminosity. Excessive luminosity is also frequently accompanied by incomplete combustion.

EFFECT OF SUBSTITUTING GASES

In order to determine the effect of substituting one gas for another a graphic procedure is used which consists in combining data from combustion data graphs

in a composite interchange chart. The procedure is simple but required a knowledge of the relative air requirement factors and heat input factors of the base and substitute gas. The procedure can best be illustrated by an example in which propane air of like heating value is substituted for natural gas. For this example we will assume 1000-Btu natural as the base gas.

The important factors involved in the interchange are given in Table I.

TABLE I

Gas	Type	H	$(H/\sqrt{d})$	$(aH/\sqrt{d})$	(Q_S/Q_B)	(P_S/P_B)
Base gas....	Natural	1000	1250	1185	.....	.....
Substitute..	C_3H_8Air	1000	910	821	0.728	1.44

In the tabulation H is the total heating value, $(H/\sqrt{d})$ is the heat input factor, $(aH/\sqrt{d})$ is the air requirement factor.

Q_S/Q_B is the ratio of heat input on substitute gas compared to that on the base gas or $\frac{(H/\sqrt{d})_S}{(H/\sqrt{d})_B}$ and P_S/P_B is the ratio of per cent combustion air on the substitute gas compared to that on the base gas or $\frac{(aH/\sqrt{d})_B}{(aH/\sqrt{d})_S}$

The combustion data graph for the base gas (Figure 1) is copied in its entirety, including graduations and scale markings, on a piece of transparent paper. A point is then located on this graph and marked "*" located as follows:

At a rate of heat input of (10,000) (Q_B/Q_S) and a per cent primary value equal to (100) (P_B/P_S), for the 1000-Btu propane-air this mark is positioned at (10,000) (1/0.728) or 13.7M heat input and at 100/1.44 or 69.4 per cent primary air. The partially completed graph is then placed on the combustion data graph for the substitute gas (Figure 2) with the mark "*" over the intersection of 10,000 heat input and100 per cent primary air value with heat input and per cent air lines parallel to those of the substitute gas chart. The curves for the substitute gas are then traced dotted on the tracing paper to complete the interchange graph (Figure 3). Since the scales are logarithmic on the vertical axis, the horizontal shift of curves relates combustion behavior of the substitute gas to burner adjustments on the base gas, and position of the dotted curves in respect to the corresponding full line curves directly indicates the relative performance of the base and substitute gas.

Referring to curve sheet, Figure 3 which combines data from Figure 1 (the base natural gas) and data from Figure 2 (for 1000 Btu propane air) in this manner, we may note a greater tendency for flash back, lifting and luminosity for the propane air. Had the burner been adjusted for 60 per cent primary air and a rate of heat input from 1200 to 15,000 on natural gas, the rate of heat input of natural gas would have to be limited to a range of 3700 to 10,000 to avoid flash back and lifting respectively on 1000 Btu propane air. Corresponding rates of heat input and per cent primary air values on the 1000 Btu propane may be calculated by multiplying scale readings of heat input and per cent primary air by factors Q_S/Q_B and P_S/P_B respectively. Obviously 1000 Btu propane air is a poor substitute for 1000 Btu natural gas not only due to flame behavior but also due to high per cent combustion air and low rates of heat input.

A much better selection of substitute propane air would be a 1440-Btu mixture which has the same air requirement factor as the base natural gas. This gas would show less lifting tendency and would require only a slight increase (about 40 per cent) in minimum heat input in order to avoid flash back on the substitute gas. This 40 per cent increase is in this case independent of burner primary air adjustment. For the 1440 propane air substitute gas, the heat input and per cent primary air would be substantially and exactly the same respectively on base and substitute gas. Only luminosity would be greater on the propane air, which might confuse furnace operators in judging combustion and would affect radiation.

Similar interchange charts may be made up by combining combustion data graphs for other gases involved in the substitution. The results are not always pleasing, particularly when we attempt to substitute a slow burning gas such as natural or propane air for a fast burning gas such as coke oven gas. The strange and the somewhat bizarre effects of such substitutions on flash back behavior can be illustrated by the interchange graph for coke oven gas and propane air. See Figure 5. Obviously propane-air of any heating value has a far greater tendency to lift than coke oven gas. Note that on Figure 4 lifting data is plotted partly as 1/10 of Q_L and partly as Q_L and on the interchange chart as Q_L. Now examine the flash back curve for 750 Btu propane air. At 50 per cent primary air adjustment coke oven gas has less tendency to flash back than the propane air. At 75 per cent primary air, coke oven gas has far greater tendency to flash back. In fact if the burner is adjusted for a minimum heat input of 10,000 to avoid flash back on coke oven gas, at 75 per cent primary air it would be impossible to burn the propane air since lifting would occur. These peculiar effects partly explain some of the peculiar and erratic results of attempting to relate gas interchangeability to test burner adjustment.

Up to this point in our discussion we have considered only complete substitution of one gas for another. Partial substitution, or so-called peak shaving introduces more complications. Where gases of similar heating value are involved, the procedure is not complicated for the combustion data chart for a mixture of two gases can be approximated by drawing intermediate curves positioned between corresponding curves in proportion to part volumes of each gas. The heat input factors and air requirement factors for the gas mixture should in all cases be calculated where densities differ.

In mixing two or more gases of unlike heating value, the calculations are complicated by the fact that some properties affecting combustion behavior are related to part volume and some to part therms contributed by each gas. Thus the lifting and flash back behavior curves for a 50-50 mix of two gases of unlike heating value are not midway between the flash back and lifting curves for the base and peak shaving gas. Thus flame velocity and "a" would be more nearly proportional to part therms. Heating value and density would be proportional to part volume. For a 50-50 mix, the difference between part volume and part therms would reach a

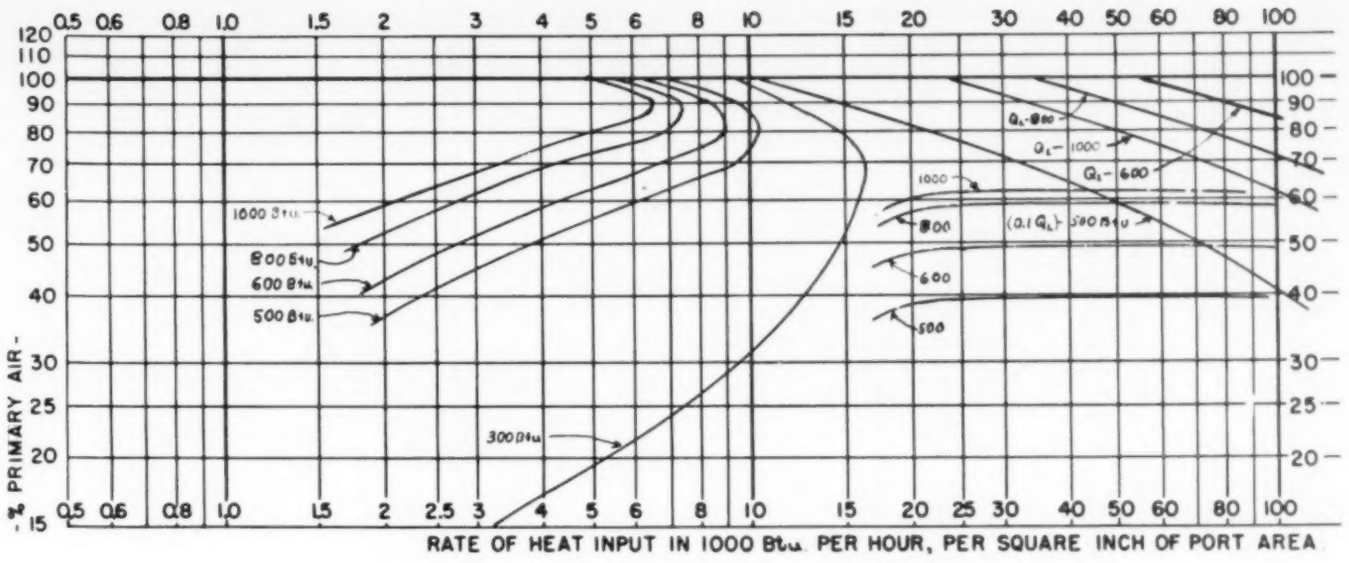


Figure 6 — Combustion data is given for water-gas.

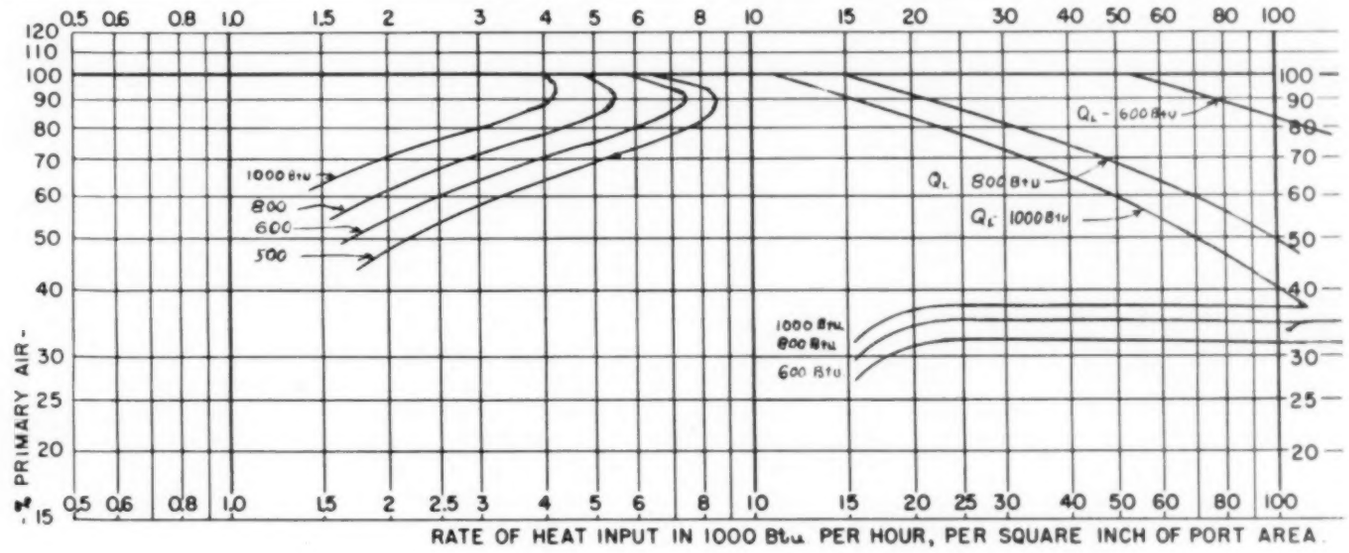
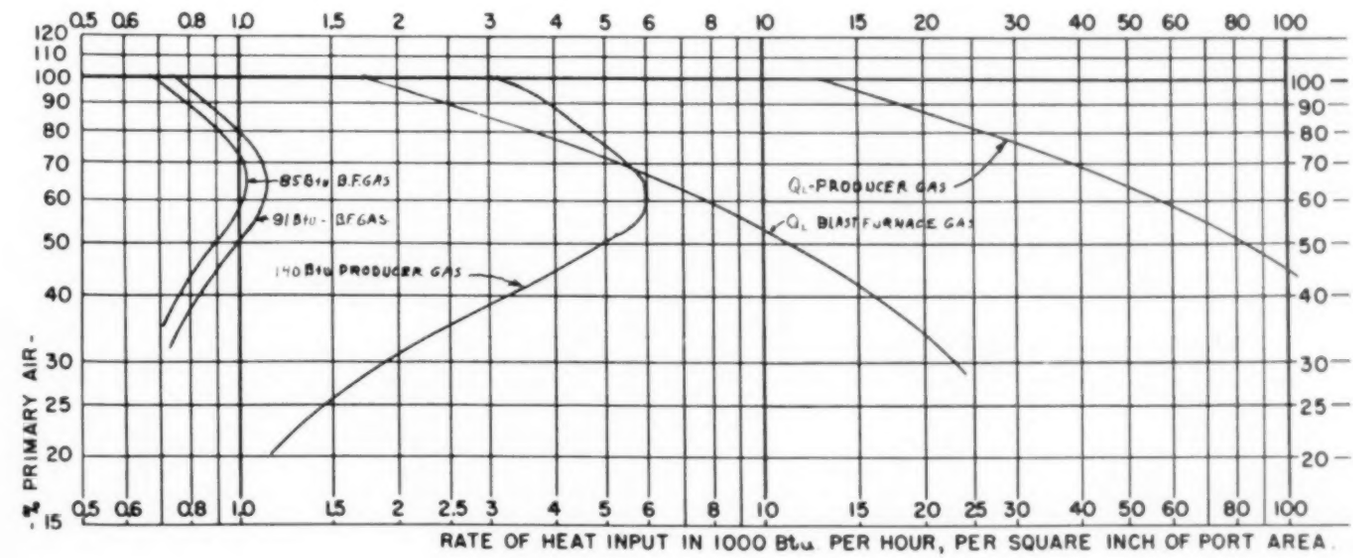


Figure 7 — Combustion data is given for oil-gas.

Figure 8 — Combustion data is given for blast furnace and producer gas.


% PRIMARY AIR
RATE OF HEAT INPUT IN 1000 Btu. PER HOUR, PER SQUARE INCH OF PORT AREA
85 Btu. B.F.GAS
91 Btu. - B.F.GAS
140 Btu. PRODUCER GAS
Q_L-PRODUCER GAS
Q_L BLAST FURNACE GAS

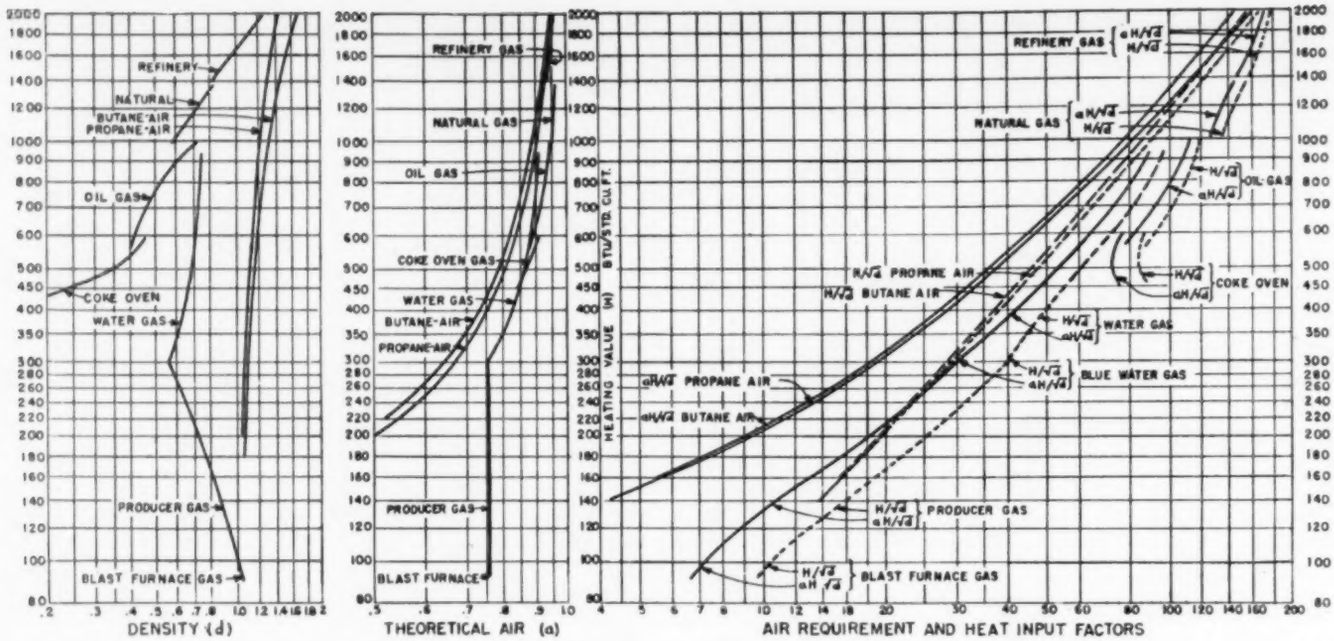


Figure 9 — Curves give properties of commercial gases which affect combustion.

Figure 10 — Calculation chart is given for a 530-Btu coke oven gas.

	PART VOLUME	Btu		DENSITY		PART Btu.	a		P_Y		P_A		P_B		P_M		S_M		S_{100}		S_{120}	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
H_2	.510	319.3	163	070	.036	.308	.745	.229	0.		5	1.5	8.	2.4	55.	17	283	97.1	189	58.2	140	43.1
CO	.080	316.	25	.997	.080	.047	.754	.037	0.		18.	.5	29.	1.7	65.	3.1	51	2.4	39	1.8	32	1.5
CH_4	.240	995.3	239	.555	.161	.547	.958	.525	23.	13	70.	38.2	86.	47.	98.	52.5	26	14.2	25	13.7	20	10.9
C_2H_6		1794		1.040			.957		35.		66.		80.		96.		32		27		24	
C_3H_8		2481		1.527			.963		41.		58.		74.		93.		30		27		22	
C_4H_{10}		3217		2.010			.963		54.		61		76.		90.		33		29		22	
C_2H_4		1572		0.97			.910		61.		52		64.		92.		65		60		43	
C_2H_2		1464		0.91			.813		150		17		33.		70.		170		120		84	
ILL	.025	2100	52	1.413	.035	.099	.950	.093	100	9.8	54	5.3	67.	6.6	90.	9.5	70	6.9	60	5.9	43	4.2
SUM		H=	529		.312	1.00		.384		32.4		47		57.4		91.3		111		79.6		59.7
O_2	.005				.005		-4.76	.024														
N_2	.015				.013																	
CO	.005				.009																	
TOTAL		H=	529	d=	.398		a=	.860	P_Y=32.4		P_A=47		P_B=57.4		P_M=91.3		S_M=95.8		S_{100}=69.5		S_{120}=57.4	
		$\frac{1220}{H}$ = 2.31		H/√d= 837			a H/√d = 721															

FLAME VELOCITY FACTOR FOR INERTS = $\frac{1}{1+2n+3m}$ = .86

PART VOL N_2 /100 Btu. = n = .014

PART VOL CO_2 /100 Btu. = m = .009

P=	0	10	20	30	40	50	60	70	80	90	100	120	P_A=47
1220/H	2.31										2.31		2.31
12 2 P	00										960		459
PORT V.	2.31	327	423	519	615	711	807	903	999	1095	1191	1383	681
FLAME V.	—	—	—	—	—	13	25	50	95	85	72	52	11.3
$(Q_F)P$	—	—	—	—	—	1.82	5.10	9.42	8.5	7.77	6.05	3.7	1.65
$(Q_L)P$	1518	1098	736	500	392	340	166	115	50	55	38	18	—

NOTES:-

(1220/H)= PORT VELOCITY FROM GAS (Cm/SEC.)

(12 2)(a P)= PORT VELOCITY FROM PRIMARY AIR.(Cm/SEC.)

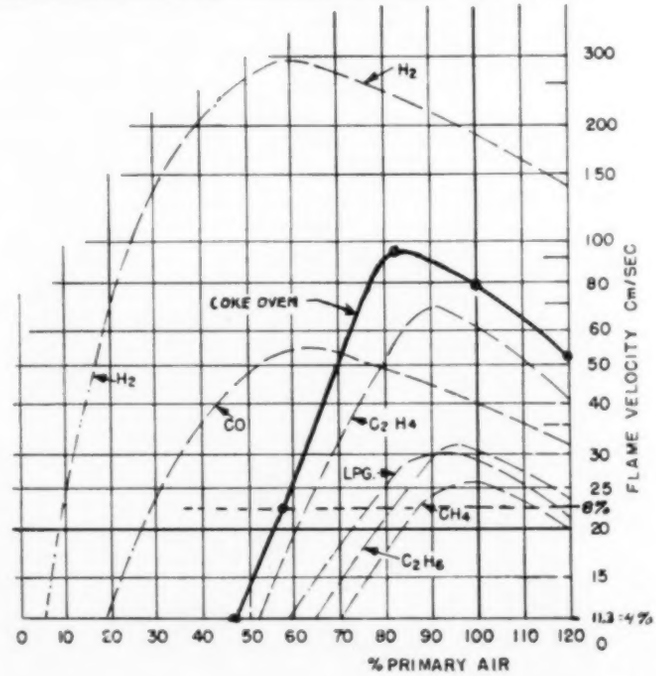
FLAME VELOCITY AT P (FROM CURVE) Cm/SEC

$(Q_F)P$ = HEAT INPUT FOR FLASH BACK

= PORT VELOCITY / FLAME VELOCITY

$(Q_L)P$ = HEAT INPUT FOR LIFTING.

$$\text{LOG}\,(Q_L)P = [\text{ANTI LOG OF}\,(\tfrac{S_{100}-12}{167})] + 1 - 0.016\,P$$



maximum. For a precise calculation of the effect of partial substitution of gases of unlike heating value it is therefore necessary to separately calculate the various factors affecting combustion behavior.

Combustion data graphs are included for a variety of gases. These data were calculated by procedures which are considered controversial by many of the experts. It is our opinion that they are sufficiently accurate for predicting burner performance and that their use will be of value to the mill engineer for guidance in making burner adjustments or for the selection of substitute or replacement fuels.

Figure 9 illustrates values of density, air requirement per unit of heat and the air requirement and heat input factors for common commercial fuels. The data are based on typical gas analysis. It should be noted that method of production and for that matter method of gas analysis would produce variations in these characteristics. Actual measurements of heating value and density are of course desirable. The data are of value in predicting approximate characteristics of mixtures of commercial gases.

Figure 10 represents a calculation chart made out for calculation of the characteristics of coke oven gas. This illustrates the procedure used in our calculation of flame behavior. Admittedly the procedure is controversial but we consider it of practical value.

Combinations of three or more gases can frequently be proportional in a manner to favor interchangeability. Thus proportions of coke oven gas, air and natural gas (or propane) can be controlled by automatic equipment to maintain both a constant heating value and constant density. Figure 11 illustrates the flow diagram of equipment of this type.

In steel mill operations, maintaining a constant heating value is not necessarily important, which greatly simplifies the problem of automatic control of admixture of a second gas (air, blast furnace gas, etc.) for maintaining a constant air requirement factor for the mixed gas.

The importance of the air requirement factor of a fuel gas in any fuel gas application is apparent. Combustion behavior in respect to flash back, lifting and luminosity on domestic appliances may be of minor significance in steel mill operations, except by inference and for those special applications which are similar in usage to those on domestic appliances. For the latter uses, the information provided should be of value in the selection of burner adjustments which will aid in adapting equipment for operation on gases of varying combustion characteristics.

APPENDIX

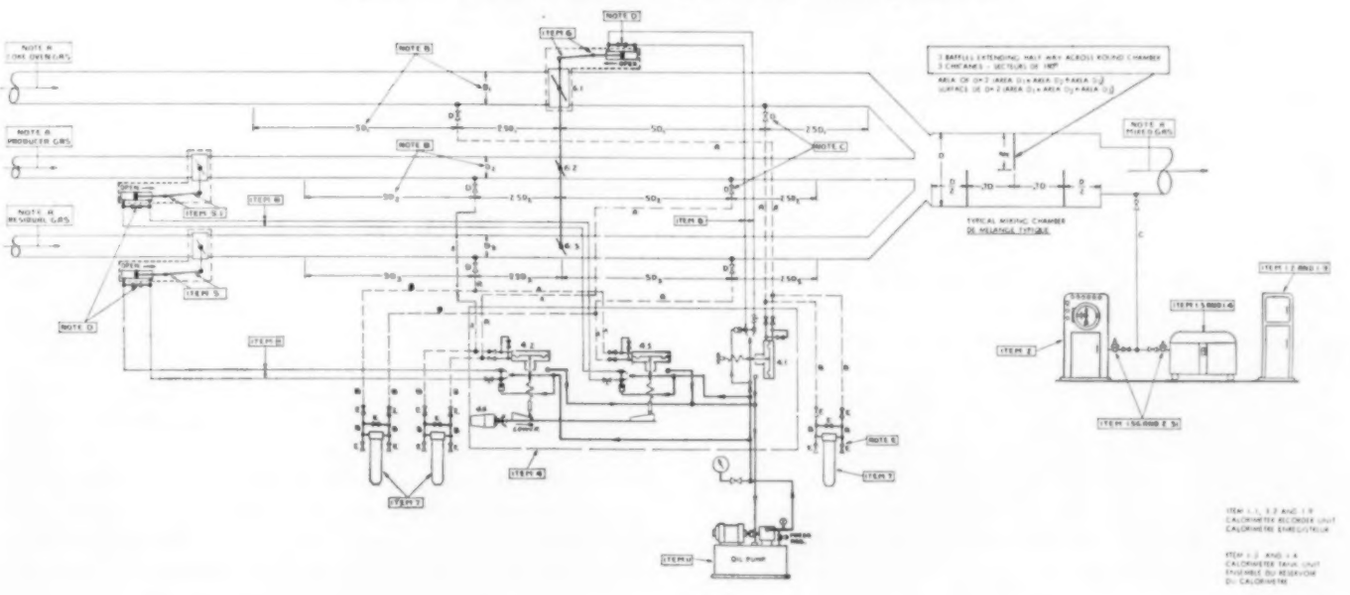
A complete bibliography for the subject of gas interchangeability would appear to be more confusing than enlightening. A rather complete bibliography is included in Research Bulletin No. 36 of the American Gas Association and in Research paper 2193 of the National Bureau of Standards by Elmer R. Weaver. Both these papers and "Interchangeability — a review" by Edward L. Hall and E. J. Weber (Publication P-C-51-2) of the American Gas Association justify study.

It should be noted that symbols and definitions used in these publications do not always agree in the different papers or with those used in our discussion, in fact in some instances the same names are used for different properties of a gas, as an example the term air requirement factor is in some instances used for the heat input factor. Note also that rates of heat input for lifting are sometimes expressed in terms of 10,000 Btu and we express them in 1000 Btu.

Statistical data presented by Mr. Weaver (Research paper 2193) indicates that relative flash back and lifting behaviors are unaffected by burner adjustment. This is probably correct for a limited range of primary air adjustment and for gases of similar flame characteristics. It is not correct for flash back behavior for gases with widely differing flame characteristics.

His statistical data indicates that maximum flame velocity (S_M) is a better index of flash back and lifting characteristics than that used in the AGA equation, which latter index for simple gases is flame velocity at 100 per cent primary air (S_{100}) and for composite gases is related to a somewhat strange combination of S_{100} and density. In our calculations we use flame velocity at 100 per cent primary air (S_{100}) in the calculation heat

Figure 11 — Schematic flow diagram for gas mixing control.



input for lifting $(Q_L)_P$ for both simple and composite gases. This procedure gives substantially the same answers in respect to relative lifting behavior as the Weaver procedure and has the advantage of showing relative values in terms of rate of heat input as a function of burner adjustment.

Preferences in choice of S_{100} or S_M as an index of relative lifting behavior is somewhat a matter of choice. The ratio of $\frac{S_M}{S_{100}}$ differs rather widely, and equations relating $(Q_L)_P$ to each would differ. Neither S_M or S_{100} is the flame velocity of the gas air mix issuing from the burner port except where burners are adjusted for P_M or P_{100} respectively. The lifting phenomena does not lend itself readily to theoretical analysis. Lifting is affected by many factors besides flame characteristics of the primary air mixture in the burner port. Thus an increment in per cent primary air of 10 per cent in primary air lowers the rate of heat input for lifting by a factor of 0.69 on practically all air free gases, even though the increase in flame velocity associated with the increment may exceed the increase in port velocity by a considerable amount. Obviously the amount and direction in flow of secondary air and/or flue gases into the combustion zone which affects the lifting behavior is a factor in the relation established by the AGA tests, and substantiated by Bureau of Mines tests for air free gases, namely that:

$$\text{Log } (Q_L)_P = K - 0.016P.$$

Expressing the AGA equation in terms of 1000 Btu per hour per square inch of port area we use the equation:

$$\text{Log } (Q_L)_P = [\text{Anti-log of } \left(\frac{S_{100\text{-}12}}{167}\right)] + 1 - 0.016P.$$

A similar equation based on S_M could be written

$\text{Log } (Q_L)_P = 0.014\ S_M + 1.85 - 0.016P$ based on the assumption that $(Q)_P$ based on the Weaver procedure for relative performance on methane will give the same heat input for lifting as the AGA procedure. For those gases for which the AGA equations are assumed to apply, (S_M and P values which give rates of heat input for lifting between 10 and 100,000 Btu), values of Q_L are substantially the same using either equation. For gases with "S" values giving higher values of Q_L, the agreement of calculated values deteriorates. In fact with high values of "S" the calculated Q_L values using either procedure appear suspiciously high.

Methods for calculating flame velocity data are always questionable. Quoting Mr. E. R. Weaver "There are many obstacles in the way of calculating flame speed, simply and accurately . . . To avoid this several assumptions have been made . . . No attempt will be made to justify them in detail." This statement applies to our procedure in calculating flame velocity data. The similarity of the Paymen method, Weaver method and our method will be apparent when we recognize the fact that the heating value of a standard cubic foot of air is not greatly affected by the composition of the gas with which it combines. In other words, the product of part volumes of gas and air per cubic of component gas divided by the air required per cubic foot of composite gas is approximately the same as the part therm input.

For our method of calculating flash back, it was necessary to determine the flame velocity curve as a function of per cent primary air. If we plot flame velocity (logarithmic scale) as a function of per cent primary air value (uniform scale) for the simple gases for which comparative data is available, the shape of the curves assume a certain degree of similarity, see Figure 10. Flames will not propagate below a flame velocity of 4 per cent of the maximum flame velocity of hydrogen, which will occur at a differing primary air value for different gases. We call this primary air value P_4. As the primary air is increased above P_4, the curve approximates a straight line which gradually curves downward from the straight line reaching a maximum flame velocity S_M and P_M and with further increase in primary air again approximates a straight line sloping downward. By determining the values of P_4, P_8, P_M, S_M, S_{100} and S_{120} for a composite gas we can then draw a curve for the composite gas similar in shape to that for the simple gases. We assume that these points on the curve can be calculated as a summation of products of these factors and the part of the total therms for the component gases. No further attempt will be made to justify our procedure except to state that the procedure appears to give results in reasonable agreement with test data.

We justify our procedure in calculating heat input for flash back by the fact that relative flame velocity data determined by making the same assumptions agree rather well with relative flame velocity data obtained by other methods of determining flame velocities.

DISCUSSION

PRESENTED BY

N. A. RESARE, Chief Design Engineer, Inland Steel Co., East Chicago, Ind.

E. X. SCHMIDT, Development Supervisor, Cutler-Hammer, Inc., Milwaukee, Wis.

W. R. FRASER, Assistant to Manager of Operations, Michigan Consolidated Gas Co., Detroit, Mich.

N. A. Resare: Although we have not experienced any full substitution of gases with butane-air, our combustion department in 1950 for a short period was faced with the problem of a partial substitution for coke oven gas. The ratio of coke oven gas to butane-air was 50-50 per cent mixture. With burning equipment used for coke oven gas unchanged, the use of this mixture resulted in a 25 per cent loss in production when used as fuel to mixing carburetors supplying radiant tube annealing covers. This was partially attributed to insufficient heat content and increased specific gravity of the mixture. When coke oven gas was increased to 60 per cent and butane-air reduced to 40 per cent, the loss in production decreased to 15 per cent.

In the soaking pits and batch type annealing furnaces, the surprising, if not unusual results were obtained when a mixture of 50 per cent coke oven gas and 50 per cent butane-air was used with no difference in performance compared to 100 per cent coke oven gas. This success was attributed to less critical burner design and the fact that the substitute fuel passed through no critical fixed orifices.

Another problem of partial substitution of gases occurred when a natural gas-air mixture was added, as a supplement, to an existing coke oven gas system. The ratio of natural gas-air to coke oven gas is not constant

since the available natural gas varies from 50,000 to 300,000 cfhr and the coke oven gas remains constant at 800,000 cfhr. It is interesting to mention that our plant has consumed the aforementioned quantities of natural gas-air mixture without experiencing any operational difficulties.

Like all other steel mills, we also use blast furnace gas wherever feasible. An example of this is in the soaking pit heating where blast furnace gas is mixed with coke oven gas to obtain a predetermined Btu value. During the past number of years no difficulty was experienced with such an installation.

E. X. Schmidt: Mr. Resare's comments are valued, and illustrate clearly some of the problems encountered in mill operation about which our knowledge of performance is limited. Mr. Resare's data is not sufficiently complete to permit theoretical calculations. Assuming that his coke oven gas had a heating value of 550 Btu and a density of 0.45 and his butane-air had the same heating value, the mixtures by volume 50-50 and 60-40 would theoretically have produced a rate of heat input of 74 per cent and 85 per cent respectively of that on coke oven gas. These figures agree substantially with the reduction in production rate reported for the premix application. We would have expected the reduction in production to be somewhat greater due to higher excess air, but of course our assumed heating values may not have been correct.

Tests on the soaking pits are of particular interest in that no change in production was noted due to substitution. In addition to the facts mentioned by Mr. Resare it might be noted that the increased luminosity of the substitute gas may have affected the distribution of heat in the system.

Supplementing the coke oven gas supply with natural gas, say 1050 Btu and 0.65 density would theoretically increase rates of heat input 5 and 16 per cent for the 50,000 and 300,000 cfhr reported addition respectively. It is possible that the temporary supplementary fuel supplies were not of sufficient duration to cause noticeable operating difficulties. Had the condition persisted for an extended period, it would undoubtedly have been desirable to dilute the natural gas supply with air to maintain a more constant heat input and efficiency.

High heating value gas is frequently added to blast furnace gas to maintain a constant heating value slightly higher than the maximum blast furnace gas heating value. In general this changes the density only slightly so that the rate of heat input on the substitute constant heating value gas remains substantially constant. On soaking pits and as fuel supply to gas engines, this has proven to be economically desirable and substantiates Mr. Resare's conclusions.

Complete information on combustion behavior would obviously be desirable, and we feel that further progress in the art should and can be attained, but we fear that as in the past the ingenuity and skill of the combustion engineer will always be required to supplement available information.

W. R. Fraser: Mr. Schmidt's approach is along the same lines as the "utilization range concept" that has been described at various times in the past. It is the kind of method of interpretation an operator can use for handling production processes. The utilization range method of handling interchangeability problems is very simple and must be experimentally determined for each gas with each kind or type of burner. The initial observations on this method of interpreting interchangeability were made on a simple gas hot plate star burner with drill ports. In this case inlet manifold gas pressures were maintained constant, and the air shutter varied between lifting and flash back and yellow tips with various gases. The thermal values of the gas in the burner throat after mixing with primary air was determined at the utilization limits of the burners — that is at the lifting or flash back points and at the yellow tipping point. Wherever the Btu range overlaps, it was found that interchangeability was satisfactory. For instance, the thermal value of throat gas when natural gas is used as fuel has a range of 160 to 260 Btu while oil gas has a range of 163 to 240 Btu and butane-air has a range of 166 to 184 Btu. Interchangeability in either direction can be obtained with these three gases when the throat gas Btu is in the butane range of 18 Btu. Outside of this range the interchangeability is poor. This same kind of data can be determined for any gas and any set of burners and give an operator a program to follow.

This method of analysis is functionally similar to Mr. Schmidt's determinations but probably would not be as exact as his method of analysis. However, the simplicity of the method is advantageous.

E. X. Schmidt: We fail to recognize the term "utilization range concept" as accepted terminology for a specific procedure or method for testing and for maintaining gas interchangeability. Neither do we recognize the similarity between Mr. Fraser's description of the procedure and our procedure.

Our procedure differs only in the mechanical process of interpreting combustion data from the latest AGA procedure, a procedure which is far more realistic than previously proposed procedures.

The use of test burners in which primary air adjustments are made to produce flash back, lifting, etc., has been and is still used to some extent as an index of interchangeability both in this country and abroad.

Unfortunately there is no instrument commercially available for the satisfactory direct measurement of gas interchangeability. This is partly due to the varied uses in which gases are used as fuels both in respect to equipment adjustment and construction.

Discussions of combustion behavior is complicated by the lack of recognized terminology for properties of the gas and factors associated with gas burning equipment which affect combustion behavior. The heating value divided by the square root of the density, which we call the "heat input factor," has been called the "utilization factor," the "Wobbe index" (European) and the "air requirement factor," by different authors. The latter name is in our opinion a misnomer because of the generally accepted definition of theoretical air. The word "utilization" frequently appears with differing interpretations.

Heating value of the gas in the burner port has been considered as an index of interchangeability, in fact the Frank Knoy index is based on maintaining supply gas composition such that a fixed heating value is maintained in the burner port. A recent publication of Mr. Knoy introduces an additional factor which recognizes the need for modification of his index to compensate for flame velocity.

By R. F. KUHNLEIN, Superintendent of Construction, Sheffield Steel Corp., Kansas City, Mo.

Scrap Preparation and Contamination

. . . . the only method of eliminating scrap contamination starts with education and ends with enforcement . . . . mill workers must be trained to observe the scrap and spot the contaminants . . . . until the steel industry requires that scrap be furnished in accordance with specification, mills will have to contend with the problem of contaminated scrap . . . .

▲ SCRAP is truly a remarkable industry. It takes the waste or by-products of the manufacturing plants, the factories, the railroads, the home—in fact every place where iron and steel are used, and transmutes it into a vital raw material. It is a commodity which is never purposely produced, yet in 1951 totalled over 68,000,000 gross tons of which almost 34,000,000 tons was purchased scrap.

There are two main classifications of scrap used in steelmaking—home scrap and purchased scrap. Home scrap, as the name implies, is the scrap produced by the steel industry itself and consists of crop ends of blooms, slabs, billets, bars and scrap from its finishing facilities. Purchased scrap is produced wherever steel is used and is collected, sorted and prepared by scrap dealers for distribution to the various mills. Purchased scrap includes scrap from industrial or factory sources, railroads, farms, auto wrecking yards, demolition projects, ships, etc. The three main sources of foreign scrap — metalworking factories, auto wrecking yards and railroads—accounted for, in round numbers, about 18,000,000 tons of purchased scrap in 1951.

We have problems with both types of scrap, but since we are able to control more closely any contamination in scrap that is produced in our own plants, it is the foreign scrap that will be discussed in this paper. Since we are a cold metal shop producing about 50,000 tons of ingots per month, scrap is an essential raw material and is very important to us. We require quantities of scrap each month that would support a much larger plant having access to adequate amounts of hot metal. Since scrap accounts for one hundred per cent of our charge, we have to be concerned about the quality of this raw material. Foreign scrap has been broken down by the Department of Commerce into seventy-five separate grades of iron and steel scrap. In this discussion, these grades will be generally classified into four major groups—cast iron, prepared scrap, hydraulic bundles and unprepared scrap.

Scrap preparation has as its purpose the readying of scrap for charging into steelmaking furnaces or for foundry use. Light scrap can be baled or bundled and all scrap can be cut small enough to give the maximum economical density in the charging pans. This size varies from mill to mill, depending upon box size, door size, handling facilities, etc.

In order to prepare scrap so as to be of maximum density in the charging pans, a scrap yard of considerable proportion has been constructed at our plant. This yard covers many acres and has several miles of track and has been laid out to allow us to do the best possible job of processing scrap for our use.

Scrap coming into this yard is inspected by the scrap preparation yard, by the purchasing department, and by the yard switching department. This latter inspection is cursory and is used in identifying cars rather than in determining grades of scrap. The inspection of the purchasing department is used to determine the grade of incoming scrap against the grade of the dealer. Any differences of opinion in this matter—and they are not uncommon—are settled before the car is unloaded. Such cars are placed on a "hold" sheet by the switching department and are held until the disposition is given by the purchasing department. After the scrap has been accepted by the purchasing department, it is directed to the department where it can best be utilized by the inspector of the scrap preparation department. Switch orders are issued by this department for the placing of cars of scrap.

We wish that we could say that these orders are always followed, but we do get cars of high quality scrap set for lower grade heats and cars of contaminated scrap set to the stockyard rather than to the preparation yard. We also get "hold" cars set at times, to the consternation and embarrassment of the purchasing department. These instances are held to a minimum, but are related here to show that our plant is no different from others. We all make mistakes.

Steel scrap in this yard is directed for preparation to one of two general areas—to the shear and press area or to the torch area. We have an overhead craneway 96 x 750 ft with a 15-ton combination grapple and magnet crane. Scrap is unloaded from incoming cars and scattered in front of a row of seven alligator type shears. From this location, the scrap is picked by the scrap pickers and the shear scrap is taken to the shear table for further preparation. The scrap pickers pile the press scrap to one side and leave the chargeable scrap and the scrap which is unsuited for shearing on the ground.

Non-ferrous metal is also picked from the scrap at this point. Certain types of scrap are not suited for shearing and are torched in this area. This scrap might be high carbon scrap or sections which would be difficult to shear without the possibility of injury to the shearsman. After this scrap has been prepared, it is picked up by the overhead crane and loaded for shipment to the stockyard. The shear scrap is cut into 18-in. lengths for the cupolas and 3-ft lengths for the open hearth and is loaded by the locomotive cranes on the outside of the building. This arrangement of shears permits our shearsmen to work under cover from weather, and out from under any overhead crane.

The press scrap picked from the scrap is sent to the press and compressed into hydraulic bundles. By collecting our press scrap entirely from unprepared scrap and certain types of heavy melting, clean bundles can be sent to the open hearth—bundles that the furnace operator does not have to worry about concerning metallic content. Production on this press of 18 x 20 x 24-in. bundles averages about 180 bundles per eight-hour turn and each bundle weighs approximately 700 lb. This gives an average density on our hydraulic bundles of 130 lb per cu ft, all of clean material which can be used in the manufacture of steel. Compare this figure with the 75 lb per cu ft specification for foreign hydraulic bundles. Considerable attention is given to removing non-ferrous materials from the press scrap.

Scrap which is unsuited for shearing—demolition type scrap, heavy railroad scrap, etc., is taken to the torch yard where it is handled by 40-ton diesel-electric locomotive cranes. Throughout this torch yard, we have oxyacetylene stations on a central manifold system for the convenience of the torchmen who are cutting the scrap. We generate our own acetylene in this department and oxygen is piped from the central distribution system.

Cast iron scrap in heavy sections is prepared in a conventional skull drop building, the typical high bay enclosed type of building where scrap is broken by dropping a large steel ball upon it.

We also have a machine driven oxyacetylene torch for the cutting of spills and peanuts, steel buttons which are too heavy to be broken in the skull drop building.

Since we are a cold metal shop, we of necessity use a large amount of cast iron in our process in the cupolas. We get a considerable portion of this cast iron by stripping automobile motor blocks.

Besides size requirements, scrap quality and alloy possibilities have now entered the scrap preparation picture. Conservation of expensive and scarce alloy material requires that scrap containing these alloys be accumulated and used only in heats where the alloy can be used. In addition to desirable alloy content, there is also the undesirable or contaminated scrap to be handled. One of our major problems at the present time—fully as important as sizing scrap and increasing density—is removing contamination, principally non-ferrous metals.

Contaminants in the scrap consist of many and varied products not suited for the manufacture of steel. Dirt in the bundles or on the scrap is harmful for the following reasons:

1. It decreases the yield.
2. It insulates the scrap from the heat and consequently increases melting time.
3. It increases slag volume; and since all refining is done under the slag, the heavier the slag the slower the transfer of heat to the metal and the longer the heat time.
4. Slag control is made more difficult.
5. Buying dirt at the current price of scrap is an expensive way to cause the open hearth operator additional troubles.

Rubber contains a large amount of sulphur; and if it is charged into the furnace, this sulphur will be absorbed by the slag and the metal. Since sulphur removal is a slow process in the open hearth, slags may be increased in volume from a normal of 8 to possibly 15 per cent, where they become almost unworkable and very costly and time consuming.

Oil and grease, which are sometimes bundled in the scrap, are detrimental to the refractories of the furnace. They may cause excessive temperatures on the roof or outgoing ends of the furnace and do their part in disrupting fuel-air ratio and in clogging flues and checkers.

Zinc in the form of coatings volatilizes in the furnace, but can be found in deposits in the checkers and flues. Heavy zinc fumes also interfere with the vision of the operators and contribute to the air pollution of the district.

Lead is detrimental to the bottoms and banks of the furnace. Lead melts at a low temperature, and due to its weight, will run to the lowest part of the furnace and will eat its way through the refractories and the furnace bottom. A channel may be formed for the heat of steel to follow the lead through this opening and into the open hearth pit. When this happens, the furnace is down for many days for repairs that are costly and tonnage reducing.

Aluminum on the banks will erode refractories. When the banks or bottom start to erode, it may be necessary to tap the heat before refining is completed to prevent break-out or time-consuming delays which would become necessary if the erosion were permitted to continue. These forced taps, besides being time consuming by delaying charging on the next heat, are also a source of steel which is often difficult for the mills to use.

Silicon either in the form of high silicon steel or coatings is detrimental to production, for the volume of slag must be increased to maintain proper lime-silicon ratios and the heat time is increased. High silicon scrap can also cause high melts because of its effect on the oxidization of carbon in the bath. High silicon slags are also highly erosive to basic banks and require quick adjustment to keep bank erosion to a minimum. These items which are listed are all contamination items which affect the operator of the furnace.

In addition to this contamination, there is also the contamination which involves the metallurgist. By that is meant the undesirable elements which affect the chemical and physical properties of steel.

Copper cannot be reduced in the open hearth and tends to build up through the circulation of home scrap. Therefore, any copper entering the steel charge remains for a long time.

Copper imparts some benefits to steel, such as increased corrosion resistance (0.20 per cent is all that is required), but it also has several harmful effects. The most important is its harmful effect on surface, commonly known as fish-scale. During heating operations, both the iron and the copper are oxidized, but the copper is immediately reduced back to copper and tends to concentrate as the steel around the copper scales away. Eventually, it becomes concentrated on the steel surface beneath the scale; and since most steel heating operations are above the melting point of pure copper (1981 F), it is in a molten condition. The molten copper then collects on the steel surface and penetrates the grain border, which permits these to open up during rolling or forging.

The amount of copper that will cause "fish-scaling" cannot be stated exactly, because it depends on the amount of scale formed during heating. This, of course, depends on the amount of fuel, amount of air used, temperature and the length of the heating operation. However, several specifications for forging grade steel specify 0.25 per cent max, while the AISI standard is 0.35 per cent max.

Another detrimental effect of copper on steel is that it hardens the steel and makes it unsuited for extreme cold drawing. This could also apply to cold heading. Most producers of cold rolled body sheets limit the copper content to 0.08 per cent max.

Some of the bad effects of copper in the steel can be overcome by the addition of nickel in sufficient quantities to give a residual one-half as much as the copper. This combination produces a higher melting nickel-copper alloy on the surface, which does not become molten at ordinary reheating temperatures, and hence does not penetrate into the grain boundaries.

In speaking of contamination of scrap, there are two types of contamination—chemical and physical. Chemical contamination can be detected only if the type of scrap is known to the yard operator as containing certain elements which may be desirable or may be undesirable. We are on the lookout in our yard for any scrap which contains nickel or manganese, and our yard people have been trained to detect this type of scrap and sort it. High nickel scrap occurs, for instance, on well drill bits and manganese scrap can be picked out from shovel teeth, crusher jaws, etc.

The physical contamination comes from non-ferrous materials which can be detected in the scrap.

Dealers' bundles appear, in some instances, to be a catch-all for all off-grade, low density and non-metallic material accumulated around a press. This can, if not detected, ruin an otherwise good charge of scrap and render the melt unsatisfactory for the grade of steel desired. On altogether too many cases, furnaces have been seriously damaged and the safety of the personnel jeopardized by the contamination in dealers' bundles and miscellaneous scrap carelessly prepared.

In an attempt to determine what is in some of the bundles, some of the plants are embarking upon a program of opening hydraulic bundles by blasting. Observation of the results of this type of inspection presents an interesting picture of what can be hidden in a bundle that is supposed to contain material for steelmaking.

All of the undesirable items not wanted in scrap can be found in hydraulic bundles. Inspection is difficult because of the skill with which these materials can be hidden on the inside of a bundle. Concrete molds, sand, dirt, tin cans, rubber tires, etc., can be wrapped and will present a fine picture to untrained personnel. Rejected bundles so carelessly prepared that the contaminated materials were visible from the outside have been wrapped and sent back to the plant again.

One of the sources of contamination in scrap which may not be known to the scrap suppliers or to the personnel in the scrap yard is lead bearing steel. One grade of this material is being produced in sizeable tonnage and is made as 4140 steel. It is my understanding that this particular grade of scrap does not affect the operation of the open hearth furnaces and has been so proven in many experiments which have been conducted with respect to this problem. Other sources of lead in the scrap are to be found in the dismantling of railroad scrap, particularly in the counterweights in the drivers of the locomotives. This material can be easily melted out of the wheels and salvaged by the scrap operator. Another source of lead which is becoming more troublesome is the hydraulic bundle. Automobile body stock presents a major portion of a press operator's supply of bundled scrap. Fender stock which has had some damage and has been leaded in the shop before painting and refinishing provides this source of trouble to the furnace operator. Since the use of this type of scrap is increasing and the attempts of the industry have not as yet been successful in clearing up bundles, this source of trouble should not be overlooked in the search for the culprit in the icicle on the bottom of the furnace. This is a serious problem, since the lead going through the bottom of the furnace in many cases is followed by the whole heat of steel.

In order to pin point some of the contamination which exists in our scrap and to give the purchasing department inspectors some ammunition with which to go back to the brokers, we have developed a method for placing the contents of a car of scrap under the critical eye of the inspectors in the scrap yard. This is a method whereby the scrap is scattered over a moving belt so that every piece can be seen without moving or looking through or under other scrap. The scrap is fed into a hopper with the overhead crane or the locomotive crane; a feeder takes the scrap from the hopper at a controlled feed and deposits it onto a moving rubber belt; the belt discharges into a car after having passed in front of the inspectors. They pick out the scrap which should be bundled, approximately 20 per cent of the heavy melting, the scrap which is to be segregated because of alloy content and the non-ferrous scrap. Some of the scrap which passes the inspectors for quality is taken at the head of the conveyor by the torchmen and cut to lengths and sizes which will give greater densities in the charging pans.

It is very difficult for a dealer to say that such and such could not be in his car of scrap when the members of our purchasing department have been called over and have watched us take that objectionable material out of said dealer's scrap. This also gives the purchas-

ing department ammunition so that they can go to the dealer and request that in the future he clean up his cars or no more scrap will be purchased from him. It is rather interesting to watch some of the dealers who are not aware that we have such a device in operation try to explain some of the materials taken out of cars that they have shipped, especially when they are standing there watching the operation. We do not have too many repeat offenses after the dealer has seen this method of inspection.

The feeder is 48 in. x 8 ft, feeding on to a 60-in. rubber belt approximately 32 ft long. The feeder operates at a speed of 20 fpm and the belt is of variable speed, but is usually operated at a speed a little faster than the feeder. This permits the scrap to string out on to the belt. The speed of the whole system depends upon the character of the scrap being inspected, poor scrap being fed more slowly so that time can be had to pick out the undesirable material.

The non-ferrous scrap picked off the belt is collected and taken to a sorting and grading building. Because of the volume of this kind of material, this department has grown to the point where we employ graduate chemical engineers to help in the sorting and grading of material into classifications which will be most saleable and usable in the operating departments. In this department, we have developed a sweating furnace, gas fired, which enables us to melt certain materials into pig form, which brings a considerably higher price on the non-ferrous market.

In order to stimulate the collection of this kind of material from the scrap being prepared, we have instituted a bonus system throughout the yard so that the men participate in the proceeds of the sale of the metals picked from the scrap. This check is paid once a year and is paid just before Christmas so as to give a Christmas check to the men of this department. This is very effective in increasing the amount of metal taken from the scrap and also is greatly appreciated by the men in the yard. The bonus is based on a percentage of the returns of the sale of the non-ferrous metals after all of the expenses connected with the collection, sorting and loading of the material are deducted, and after the scrap value of the material as metal is deducted. After this has been done, the men receive 20 per cent of what is left, and it is divided among them on the basis of hours worked during the collection period.

Besides the incentive for the non-ferrous metals mentioned, there is also an incentive plan developed for the entire yard. This plan is based on the production of the various units in the yard and is paid on a bi-monthly basis. This conforms with the pay schedule in our plant. The incentive is yard-wide and is based on the one-for-one plan of payment. All of the employees in the scrap yard are on this plan, and it has proven to be very satisfactory, both to the men and to the company.

One of the things that is stressed in the preparation yard is safety. In our yards, safety comes first, and that is more than a phrase from the safety department. Because of the hazardous nature of the materials handled and the conditions under which the work must be done —snow, ice, etc.—we have devoted a great deal of time and energy to the simple matter of housekeeping. We find that housekeeping, if it is good, will help the production of the yard and also the safety of the yard. This has been brought out rather forcefully on many occasions in the investigation of some of our minor accidents; many of these minor accidents could have been prevented had the housekeeping been in order. A clean yard is easier to work in, and after a while we find that the men take pride in keeping the yard and their work areas in good top shape. All of the safety equipment that is needed for the various jobs is provided, and we insist that it be worn. This was not brought about by an easy waving of a wand and getting the men to comply at once—it took a great deal of sales work.

One of the methods used in the selling of some of the equipment was to get the men to study the jobs and to make recommendations on the type and amount of safety equipment that they thought would be necessary to safely perform the work. It is interesting to note that in many cases more equipment and safety devices were recommended than we had previously thought necessary. We have also had to guard against too much safety equipment. We have been in some yards where the torchmen and the scrap pickers could hardly get around for the amount of safety equipment that they were required to wear. We feel that safety equipment to be effective must be comfortable and easy to wear and that the men must want to wear it. This latter qualification is aided by getting the men to help develop safe practices in the yard.

This is not intended to be a complete list of the problems connected with scrap contamination. There are others. Undoubtedly, the list of things that causes trouble for one operator will not be the same list that is causing another operator trouble. The method of elimination of scrap contamination is not anything new or startling. It is a program which has long been known, but has not been followed. The only method of elimination of scrap contamination begins with education and ends with enforcement. Education is the essence of any program that would have as its purpose the betterment of scrap. There are two places where the education must be supplied and applied; first, the workers in the mill must be trained to observe the scrap and to spot the contaminants before they are charged into the furnaces, and having spotted the objectionable material to remove it from the charge; second, the workers in the supply industry must be trained to observe the scrap and to spot the contamination, and having spotted the contamination, to remove it from the scrap.

This can be done by contact with the scrap broker, by keeping him informed of the requirements and specification and by making sure that he understands that these specifications will be enforced. The broker can be kept informed of the various troubles the different kinds of scrap caused and he can pass this information along through the various channels of scrap supply and can enforce the buyers' demands and requests, particularly when it is enforced with rejections and reductions. This program cannot be successful if it is carried on by one mill or even by one district. Until the steel industry requires that scrap be furnished in accordance with prepared specifications, we will have to put up with the problems of contaminated scrap.

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Rational Distribution of Stock in a Blast Furnace

By T. AN. TESCH
Stockholm
Sweden

▲ IT is a well known fact that the stock charged into the blast furnace does not settle in a horizontal stockline, nor does the stock sink uniformly. Close studies of these problems have been performed on models. Unfortunately these tests may not be considered to reflect actual conditions, as the models employed have been too small, and due consideration has not been given to the upward flow of gases.

When a mixture of stone, crushed ore, sinter, coke, etc., of different sizes is dumped on to a slope, there will be a certain separation as the coarser pieces roll down the slope and the finer ones remain nearer the top.

When charging shaft furnaces with material of various sizes, it is therefore important that the material is supplied to the furnace so as to result in a homogeneous density of the charge. If the furnace is to operate economically and without disturbances, the upward flow of gas should be uniform throughout a horizontal section of the charge.

Two extreme examples of charging in shaft furnaces may now be considered (Figures 1 and 2).

In the case of Figure 1, the charge is dropped centrally from the conical hopper by raising the bell, resulting in the stock forming a conical heap with its lowest point at the periphery. The finest part of the stock forms a core in the center of the shaft, which to a considerable extent obstructs the flow of the ascending gases. This method of charging is nowadays generally abandoned.

In the case of Figure 2, the bell is lowered instead of raised and the conditions are reversed. The highest point of the charged stock will lodge at the periphery of the furnace and the lowest point will be in the center of the charge. The highest density of the stock will be at the periphery, although the density is less pronounced than in the center in the case of Figure 1, because the spreading area is so much larger. Blast furnace tops of this type are very common, generally arranged with an upper small bell and a lower larger one.

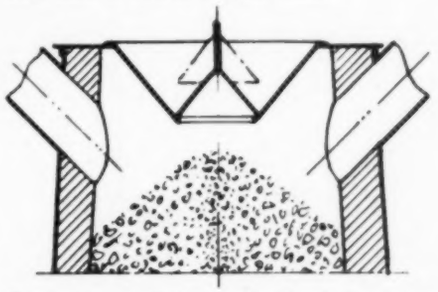


Figure 1 — This method of charging leaves the stock high at the center of the furnace.

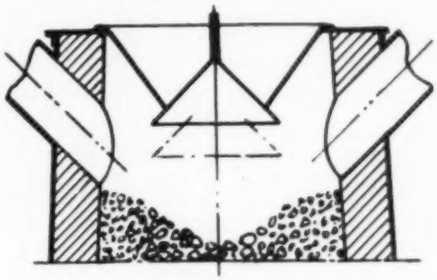


Figure 2 — This method of charging leaves the stock high at the edges of the furnace.

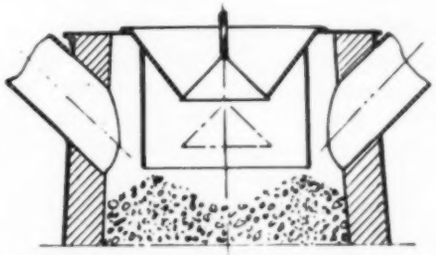


Figure 3 — A more even distribution is given by this method of charging.

Figure 3 shows an arrangement similar to that illustrated on Figure 2, but in this case a vertical cylinder or skirt guides the stock so that it forms a concentric ring between the periphery of the shaft and the center. The larger pieces will then drift partly to the center and partly to the periphery while the finer stuff remains in the concentric ring between the center and the periphery.

A NEW CHARGING METHOD

After much study, a new charging and distributing system has been designed that can charge more or less of larger or smaller particles in practically any concentric horizontal ring of the stockline, as desired by the operator. This system has been patented in several countries and patents are applied for in others.

In order to confirm the correctness of the design, practical studies were made at Oxelosunds Jarnverks Aktiebolag at Oxelosund, Sweden. These tests were quite successful and the Oxelosund concern ordered a complete top for a blast furnace with a top diameter of 14 ft-1 in. and a capacity of about 400 tons of pig iron in 24 hours. The order also comprised incline with skips, automatic electric hoist, rotating distributor, etc. The installation was put in operation in May, 1954.

The apparatus used for these tests is shown in Figure 4.

The receiver "A" represents the top of the furnace shaft and has a diameter of 4 ft 3 in. and an effective height of 5 ft 7 in. The bottom is perforated to allow the passage of the blast through the 8 in. air box below. Receiver "A" is divided by a glass pane, dividing the charge into two equal parts.

Hopper "B" is closed at the bottom by cone "C," which is movable upwards from its closed position. Somewhat below is shown a slightly smaller cone "D" which may be pulled up until it is covered up by cone "C." Its movement is therefore above and below the seat for cone "C." It is not intended to seat tightly but merely to guide the stock to be deposited near the periphery of the shaft. "E" is a stationary cylinder with conical top which serves to guide the stock towards the periphery.

From the sketch it can be seen that

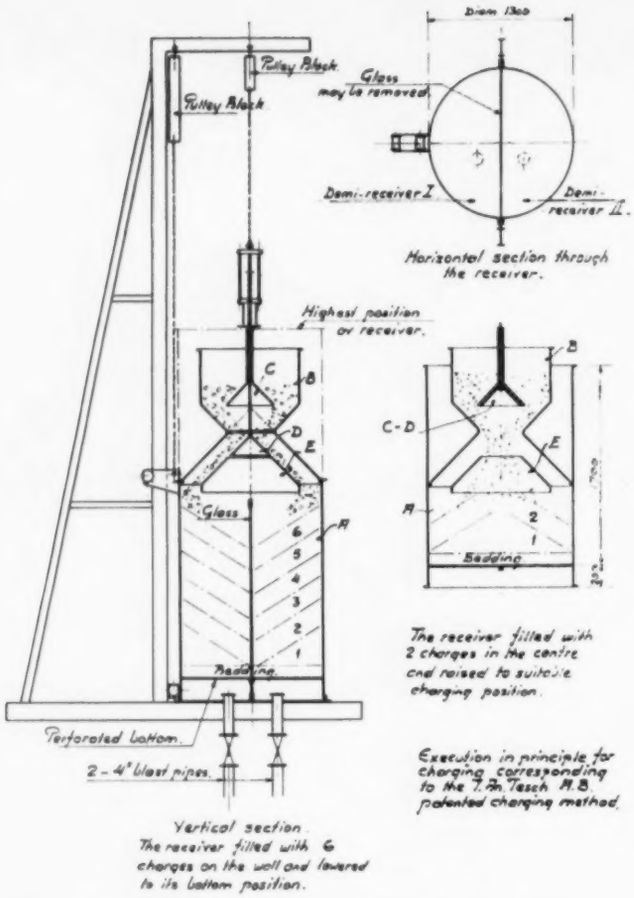

Pulley Block
Pulley Block
Glass may be removed
Dami-receiver I
Dami-receiver II
Horizontal section through the receiver.
Highest position of receiver.
Glass
Bedding
Perforated bottom
2 - 4" blast pipes
Vertical section
The receiver filled with 6 charges on the wall and lowered to its bottom position.
The receiver filled with 2 charges in the centre and raised to suitable charging position.
Execution in principle for charging corresponding to the T. Sh. Tasch. A. B. patented charging method.

Figure 4 — This test apparatus was used to determine uniformity for blast furnace charging.

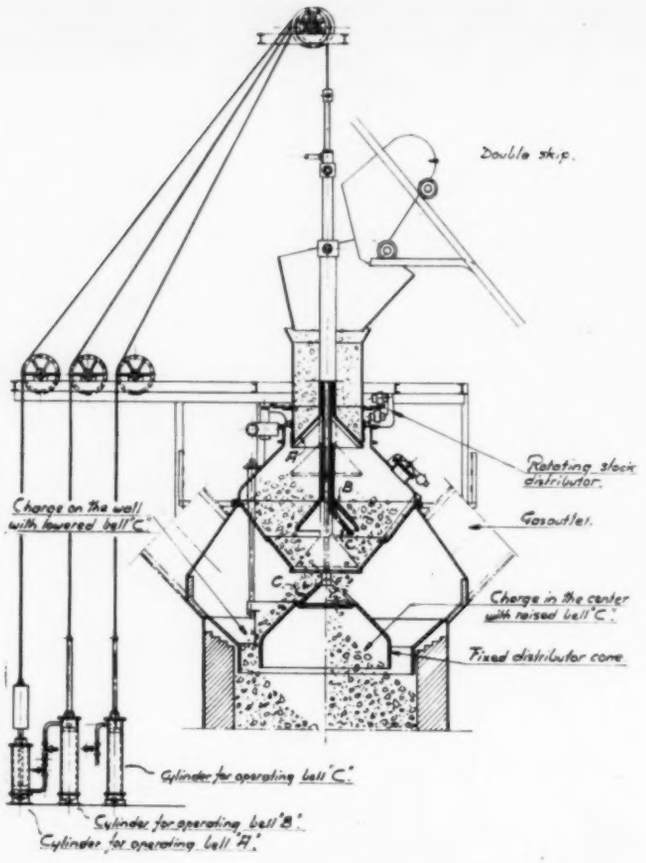

Double skip.
Rotating stock distributor.
Gas outlet.
Charge on the wall with lowered bell "C".
Charge in the center with raised bell "C".
Fixed distributor cone
Cylinder for operating bell "C".
Cylinder for operating bell "B".
Cylinder for operating bell "A".

Figure 5 — Blast furnace top shown gives selective charging on the wall. This may be satisfactory for furnaces with diameters under 15 ft.

the position of the bells "C" and "D" on the section to the left distributes the stock to the periphery, whereas their position on the section to the right guides the stock to the center.

The receiver "A" may be hoisted by pulley blocks. When beginning the charge, the empty receiver is lifted to its highest position — see dash and dotted lines on the section to the left — and it is then lowered for each additional charge so that the fall for each charge will be the same.

Measurements of air velocity were made across the test furnace, and the irregularity of flow was related to an ideal line or average permeability. These results for the different tests are given in Table I.

The figures given within parentheses apply to the permeability for the air after the charge has been made level by hand. Although stock was level, segregation of fines and coarser sizes, still gave a variable resistance to air flow.

The tests revealed that the air at the upper layer of the charge seeks to escape at such points where the surface of the charge has sunk. To measure the air at a line representing a horizontal section of the charge, may therefore be considered legitimate.

TABLE I

		Variation in air velocity from average, per cent	
Test 1 — Charges on the wall only		± 40	
Test 2 — Charges in the center only		± 38	(27)
Test 3 — Charges on the wall and in the center in ratio	1:1	± 17	(15)
Test 4 — Charges on the wall and in the center in ratio	1:2	± 25	(13)
Test 5 — Charges on the wall and in the center in ratio	2:1	± 12	(6)
Test 6 — Charges in the middle zone only		± 30	(23)
Test 7 — Charges on the wall, in the middle zone and in the center in ratio	1:1:1	± 9	(2)
Test 8 — Charges on the wall, in the middle zone and in the center in ratio	1:2:1	± 11	(4.5)
Test 9 — Charges on the wall, in the middle zone and in the center in ratio	2:1:1	± 27	(22)
Test 10 — Charges on the wall, in the middle zone and in the center in ratio	2:2:1	± 17	(12)
Test 11 — Charges on the wall, in the middle zone and in the center in ratio	3:2:1	± 15	(11)

From these results, it is evident that the charging method is of great importance for the output and even operation of a blast furnace.

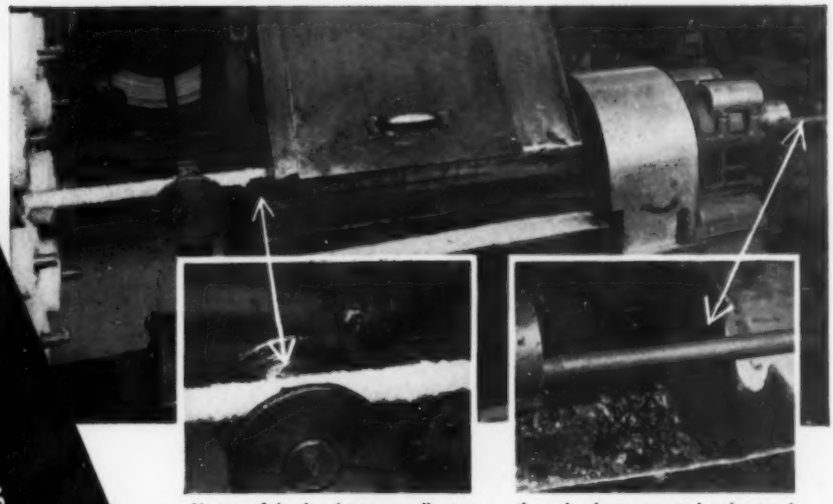
By charging on the wall, in the middle zone, or in the center only (Tests 1, 2 and 6) the distribution of the gas in the furnace shaft is very irregular. On the other hand a very good distribution of the gas may be attained by suitably changing the placing of the charges (Tests 3, 4, 7 and 8).

As the charge descends in the furnace, a certain thinning out of the accumulated concentrations of the material takes place owing to the finer particles descending faster than the coarser ones. By varying the charges deposited in the different horizontal zones, it is believed that the equalization takes place more rapidly than if all charges were deposited respectively on the wall, in the middle or in the center. This seems logical as the coarser accumulated goods are always to be found directly under the accumulated finer particles.

For furnaces with larger top diameter, for example 15 ft or more, it is important to build the top for selec-

look beneath the braid

...that's where quality begins



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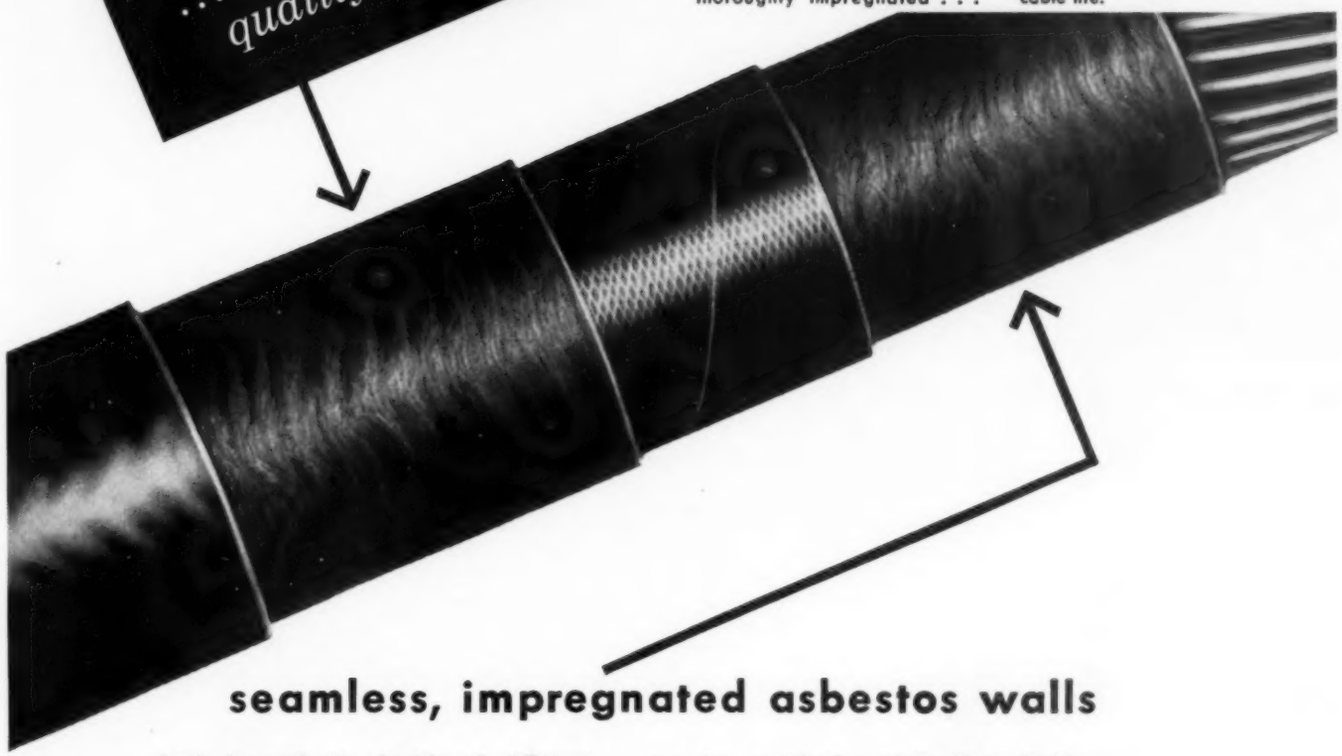

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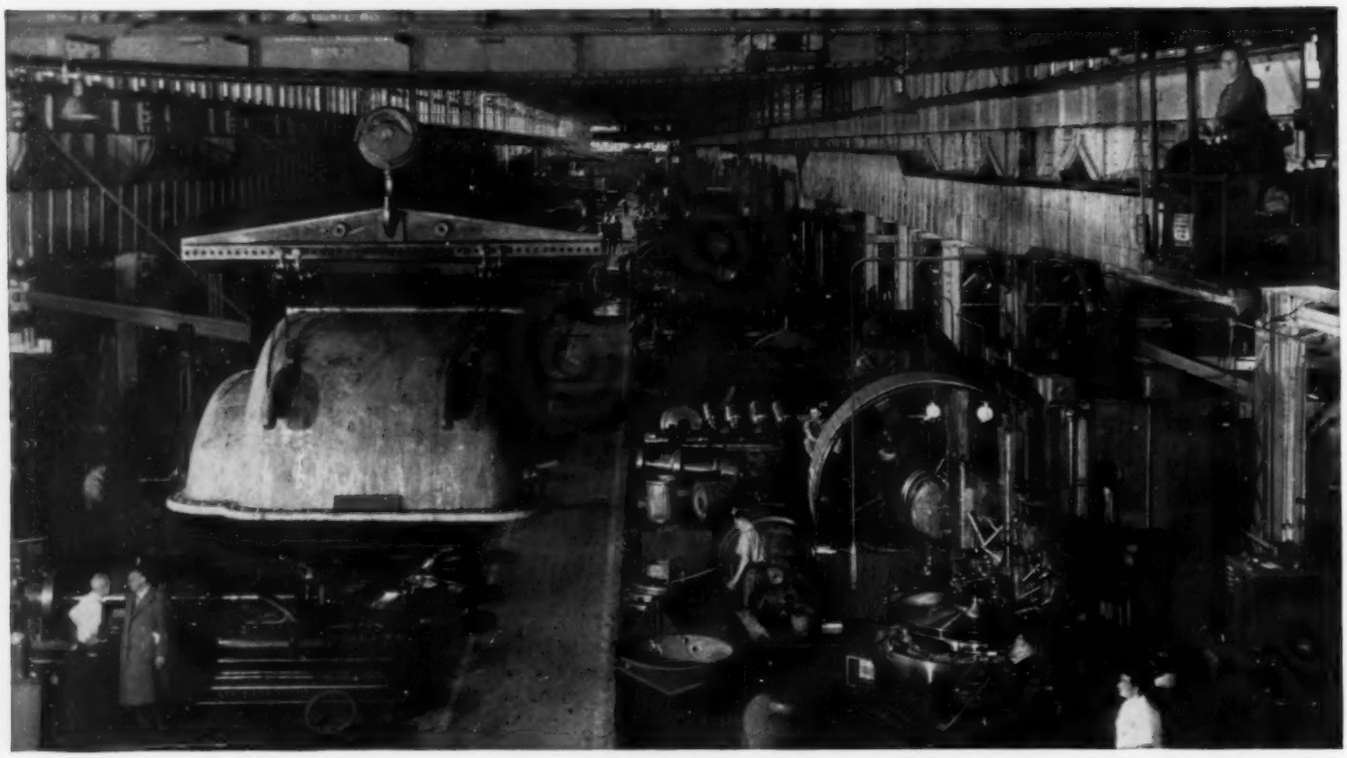

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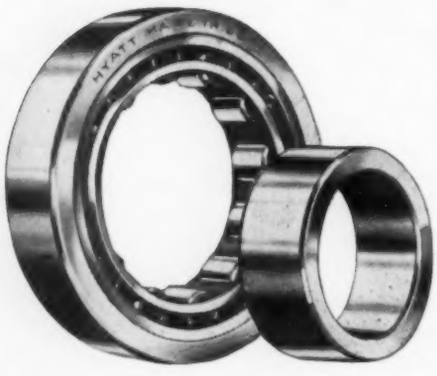

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tive charging, i.e. on the wall, in the middle zone, or in the center. For furnaces with less than 15 ft diameter at the top, it would be sufficient to build the charging arrangement to obtain selective deposit on the wall and in the center.

For furnaces with large variations of the charge, it would be very useful to use a properly dimensioned test model to ascertain the most suitable selective distribution of the charge for the different stocks to be employed.

The design of a top with double bells, arranged so that a selective charge on the wall and in the center may be obtained, is shown on Figure 5.

There are two counterbalanced self-dumping skipcars which are filled from scale cars and bring the stock from the bins in the stockyard to the skip.

The cylindrical receiver under the dumper hopper is provided with a rotating automatic distributor of generally adapted design. The bell "A" serves to sluice the goods from the upper to the lower hopper and is manipulated by a hydraulic piston in a cylinder at ground level through lever and counter weight.

The intermediate bell "B" is always lifted up in the upper position when the stock is charged into the furnace.

When charging in the center is required, the lower bell "C" is raised as shown to the right on the lower part of the section. It is lowered for the purpose of charging on the wall as shown to the left on the lower half part of the section.

The bell "B" is manipulated by means of a hydraulic cylinder with lever and the bell "C" by another hydraulic cylinder. Both of these and the hydraulic cylinder for bell "A" are placed on the ground floor, at a convenient spot such as the hoisting engine room.

The bell rods consist of heavy pipes concentrically assembled. In order to prevent dirty gas from leaking and passing upwards through these, provision is made for forcing clean cool gas downwards through the channels between these rods, escaping into the furnace.

For blast furnaces with large top diameter, a suitable arrangement is shown on sketch in Figure 6. By means of this arrangement the stock may be selectively charged on the wall, in the middle zone or in the center.

The top is principally designed as previously described in Figure 5 with bells "A," "B" and "C." Below the hopper extension are two fixed concentric cylinders prolonged upwards with frustrum of cones ending on two levels — see drawing. To the right are three sections, the upper indicating the location of the bells "B" and "C" for charging on the wall. Below this there is a section showing the location of bells "B" and "C" for charging in the middle zone and finally the lowest section shows the position of bells "B" and "C" for charging in the center.

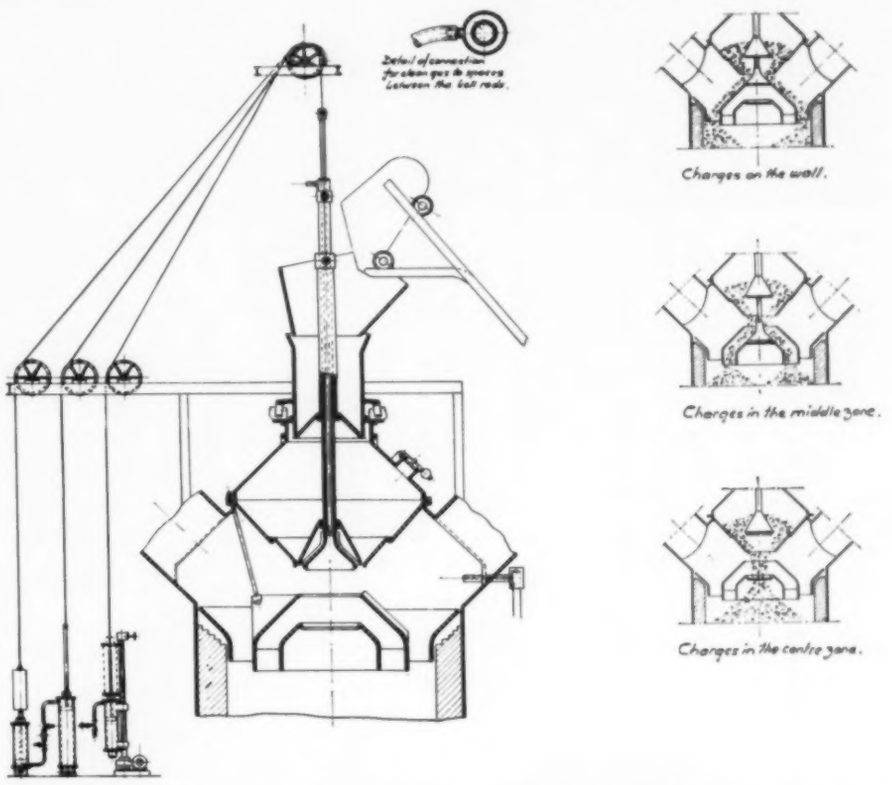

Figure 6 — This blast furnace top has three selective charging positions of the bells and can be used with furnaces of large top diameter.

In the first case, the bell "C" covers the opening of the frustrum of the distributor "D," in second case it covers the somewhat lower opening of the frustrum of the distributor "E," whereas in the third case the bell "C" is hoisted into the bell "B" leaving the openings of the two frustrums open. The operation of the top may be carried out entirely automatically with three operating cylinders.

The operation of the bells and the mechanism for the revolving top is obtained in combination with the testing rod by means of an ingenious arrangement for which patents have been applied. This device is set after a charging program has been established which is based upon the desired distribution of the stock on the wall or in the center, so as to secure an even distribution of the ascending gases.

It is evident that if a blast furnace is improperly operated, the top may be damaged because of too high top temperatures. Generally, such an accident is because the stock is allowed to sink too low into the furnace. This may happen if by some misfortune the charging apparatus is slowed down or stopped, so that the stockline in the furnace sinks without the blast being reduced or taken off. For this reason a thermostat is built in at the top and so arranged that if there is any indication of a rise above normal temperatures, a loud signal is given in the blowing engine room to warn the operator, and should the temperature nevertheless increase, the blowing engines will be brought practically to a standstill by automatic means.

The great influence which this manner of charging has on the operation of a furnace is further confirmed by certain tests made by the superintendent of a large Swedish coke blast furnace.

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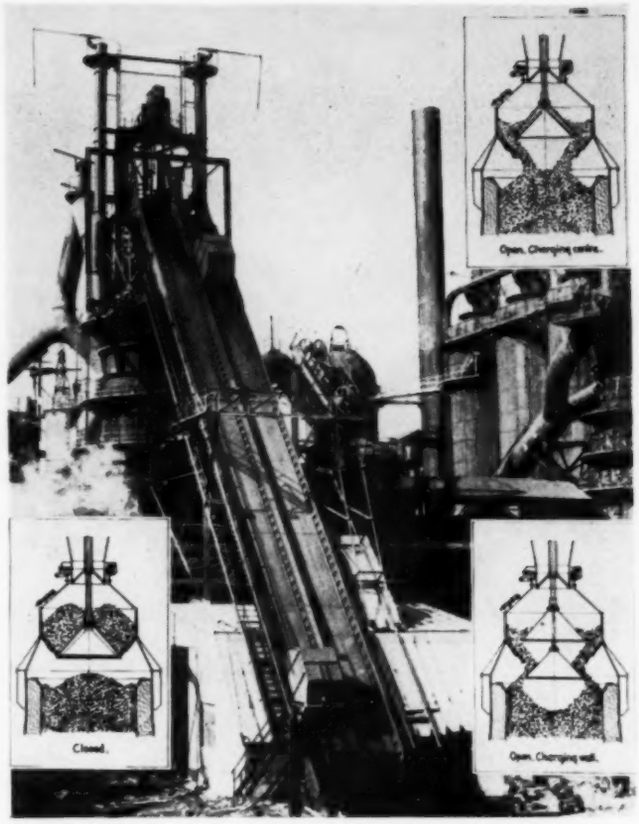


Figure 7 (left) — The selective charging system has been installed on furnace No. 2 at Oxelosund, Sweden. Figure 8 (right) — A hydraulic system gives automatic operation of the bells.

This furnace was charged solely on the wall.

This test was conducted on two levels in the upper part of the shaft in such a way that iron rods were driven to the center of the shaft. The bars, when pulled out, showed that the center was red hot but, on the other hand, that a wide concentric middle zone indicated no red heat. On the lower level, however, it was noticed that a narrow concentric ring near the wall was red hot. This seems to indicate that the density of the charge at the wall is diminished lower down in the shaft. The reason for this is undoubtedly that the fine material is thinned out, partly because it descends quicker downwards than the coarser stuff, partly because the diameter of the shaft is widened.

The revolving top has been fairly universally adopted for the charging of blast furnaces. The principle of this device is ingenious, and its introduction in the blast furnace practice has certainly involved saving in operating costs which should not be underestimated. However, its principle is limited to a distribution of the stock in the hopper and on a bell of conical section — the large bell. When this charge, on lowering the bell, is deposited in the furnace it takes a shape or profile with an unavoidable classification of the stock in larger and smaller pieces.

The selective distributor makes it conveniently possible to charge varying parts of the stock on the wall, in the center or in an intermediate zone. With this device the charge may be varied and deposited at will in any zone in quantities from 0 to 100 per cent.

There is nothing to prevent the application of a rotating distributor in combination with the selective distributor.

The costs for this new charging arrangement are not much higher than the corresponding costs for a top of classic design. In all events, the comparatively small difference in price would not represent more than the gain in better economy during a few weeks run of the furnace.

The operation of the bells are automatic and a diagram-table at the foot of the incline shows at any time the position of the bells and the testing rod.

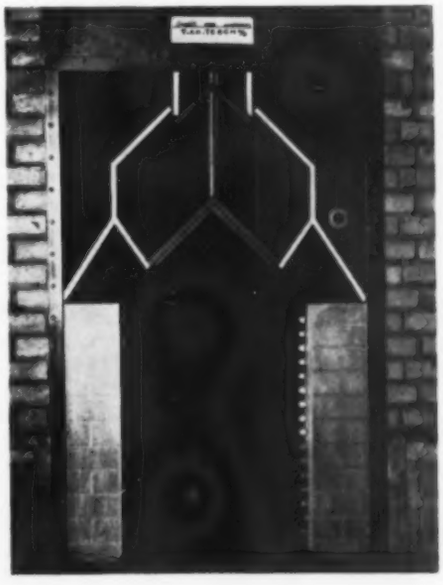
By watching the operation of the furnace it is very easy for the operator to find the variation most suitable for his operating conditions in order to obtain the best possible economy.

Another advantage which may be available is the possibility of using a larger percentage of fines than with a top of classic design. The selective charging system described results in an appreciable economy of fuel, increased production, and even and uniform operation.

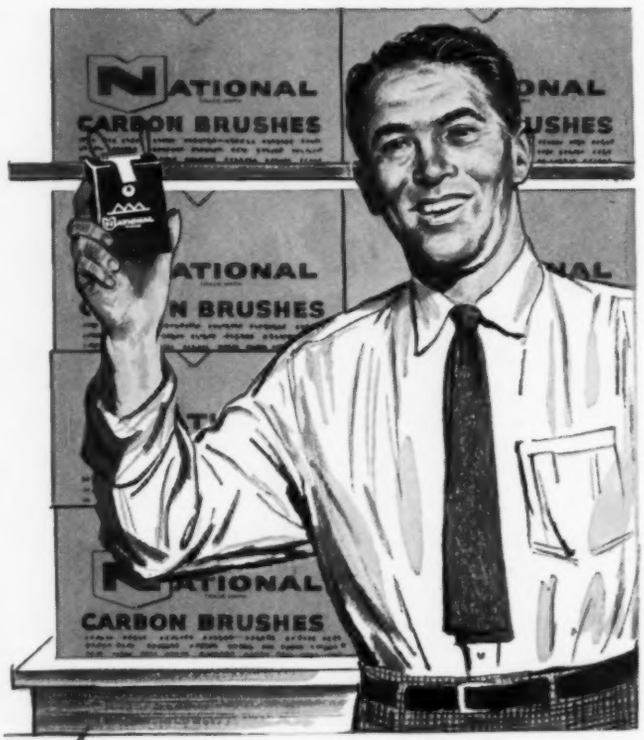
PATENTS

British Patent No. 668,702; British Patent No. 669,228; USA Patent No. 2,674,382; USA Patent No. 2,667,278.

Figure 9 — An indicator shows stock line and movement of bells.



BEST BRUSH...



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Combustion Engineer
Pittsburgh Works
Jones and Laughlin Steel Corp.
Pittsburgh, Pa.
and
HERBERT W. PETH
Consulting Engineer
Peth and Reed
Pittsburgh, Pa.

Automatic Steam Generation with steel plant by-product fuels

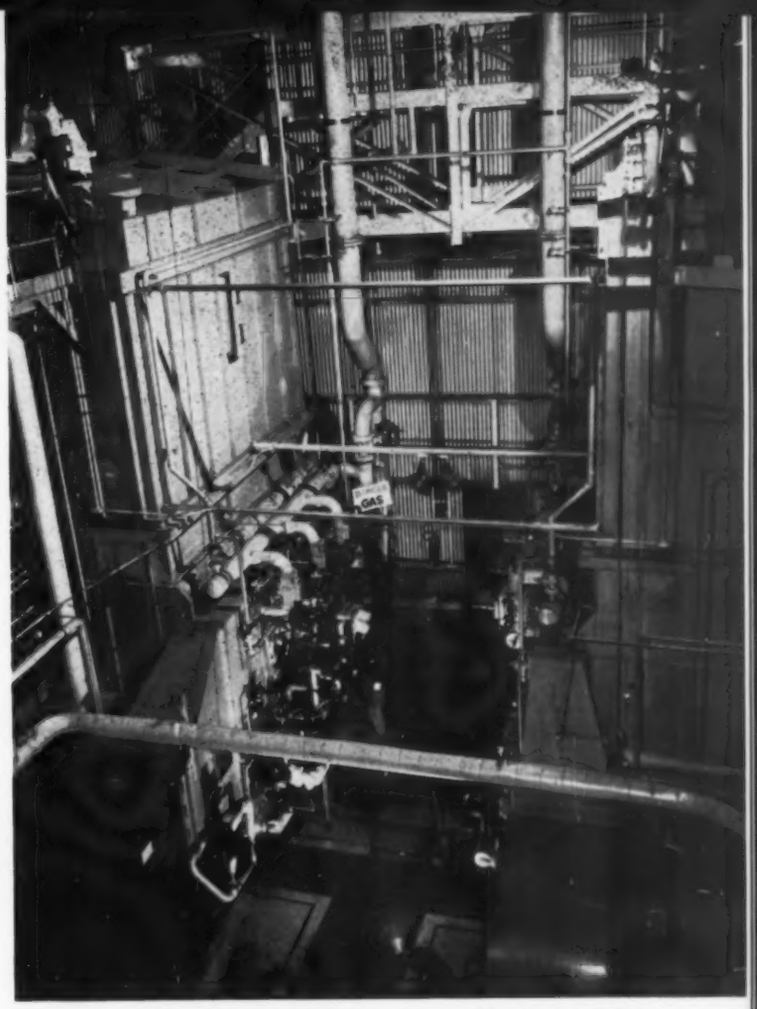


Figure 1 — View shows aisle between new No. 2 and No. 3 boilers.

▲ MAXIMUM provision for uninterrupted automatic generation of steam characterizes the design of the new 180,000-lb per hr Hazelwood by-product boiler house of Jones & Laughlin's Pittsburgh Works. Three Riley RX 60,000-lb boilers, with peak capacity of 75,000-lb each, use coke oven gas as primary fuel. Auxiliary supplies of hot residual tar and plant gas are available for makeup or emergency.

. . . . new boiler house at Hazelwood by-product plant of Jones and Laughlin is technically unique for number and variety of controls and interlocks . . . . coke oven gas-fired boilers automatically integrate with and supplement coke breeze-fired old boiler house . . . .

Automatic controls, largely pneumatic, provide for utilizing the high swing load characteristics of the new facility to balance the low swing of the nearby 160,000-lb per hr coke breeze-fired "old boiler house." The latter, with eight 20,000-lb units, is permitted to operate steadily at its maximum efficiency. Between them, the new and the old facility can burn to advantage at one time any two or all three of the by-product fuels produced by the Hazelwood plant.

The combustion control system, with its associated interlocks, was designed to assure a continuous supply of 195 psig steam for process purposes in spite of any foreseeable difficulties, including temporary power failure. For example, sudden failure of one of the 20,000-lb coke breeze-fired boilers in the old facility can be compensated for immediately by the swing capacity of the new plant. Other types of failure which will not interfere with steam generation include: failure of any one of the three burners in each boiler; failure of plant air; failure of the primary water supply; failure of any feedwater pump (there are three of these, one electric and two steam turbine driven, each with sufficient capacity for all three boilers); failure of any single valve or control element generally. The combustion control system was furnished by the Hagan Corp.

All operating controls are remote and panel mounted. There is a panel for each boiler and a master panel for the entire facility, all side by side. To switch from automatic to manual operation of any particular control, the operator turns a knob which generates a pneumatic signal which is substituted in the control system for the automatic signal. Before switching back to automatic, he must balance the two dials on the panel so that at the moment of switch the manual signal matches the automatic.

Use of the pneumatic instrumentation permitted standardization and

provided built-in "smoothing" which avoids hunting or cycling without incorporating additional feedbacks solely for that purpose. Where this lag is not desirable, as in the gas pressure control system, it is avoided by incorporating remote switching.

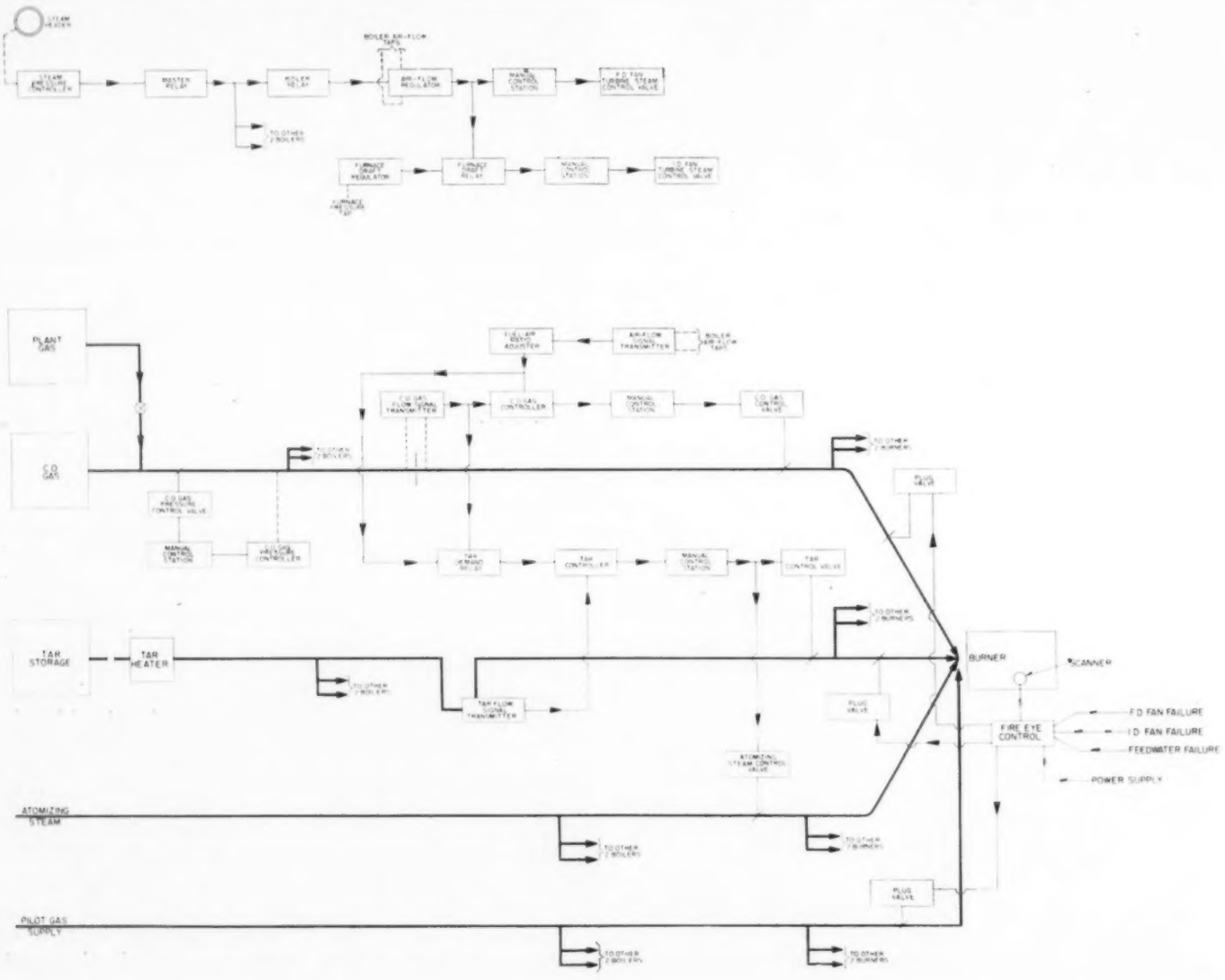
Unlike most automatic combustion control systems, where air is supplied to mix with the fuel, this facility reverses the order. Whenever steam header pressure falls below 195 psig (remember that both the boiler houses feed this same header), a demand signal is generated. This demand signal increases the flow of combustion air by speeding up both the induced and forced draft turbines. This increase in air flow in turn generates a demand signal which results in increasing the flow of fuel according to the predetermined ratio.

Advantages of this reversed order fuel-air relationship are several. Notable is that air for purging is always available in event of flame failure. If all three burners in a boiler go out simultaneously, the fire eye electronic flame scanning system shuts off the fuel immediately at each burner. Fan turbines, however, continue to turn at a preset minimum speed, automatically purging the boilers and preparing them for the relighting cycle involving the safety interlocks. If only one of the three burners fails, the fuel supply for that particular burner is shut off by the fire eye, but the total air flow continues as before and the total fuel flow continues, but channeled into two burners rather than three. Production of heat remains constant and steam generation remains constant.

Power failure is eliminated as a cause for shutdown by a combination of devices and methods, unique at the time of design. Certain of the safety interlocks and the nine fire eye flame scanning systems are dependent upon an uninterrupted supply of plant a-c power. The latter are put out of operation by even a temporary voltage drop.

An interlocked spring-loaded solenoid operated valve system, however, shuts off the instrument air supply to the individual burner fuel safety shut-off valves at the moment of plant power failure. This permits automatic control to continue and attracts the attention of the operator by a combination visible and audible alarm system powered by an independent direct current supply. Emergency lights are also fed by this independent d-c supply. If the power failure proves only temporary, the operator restores the fire eye controls individually and thus shuts off the audible alarm. If the power failure should be of longer duration, the operator can substitute manual control and operate as conditions indicate.

Figure 2 — A complete interlocking system is used in combustion control of the new power plant.



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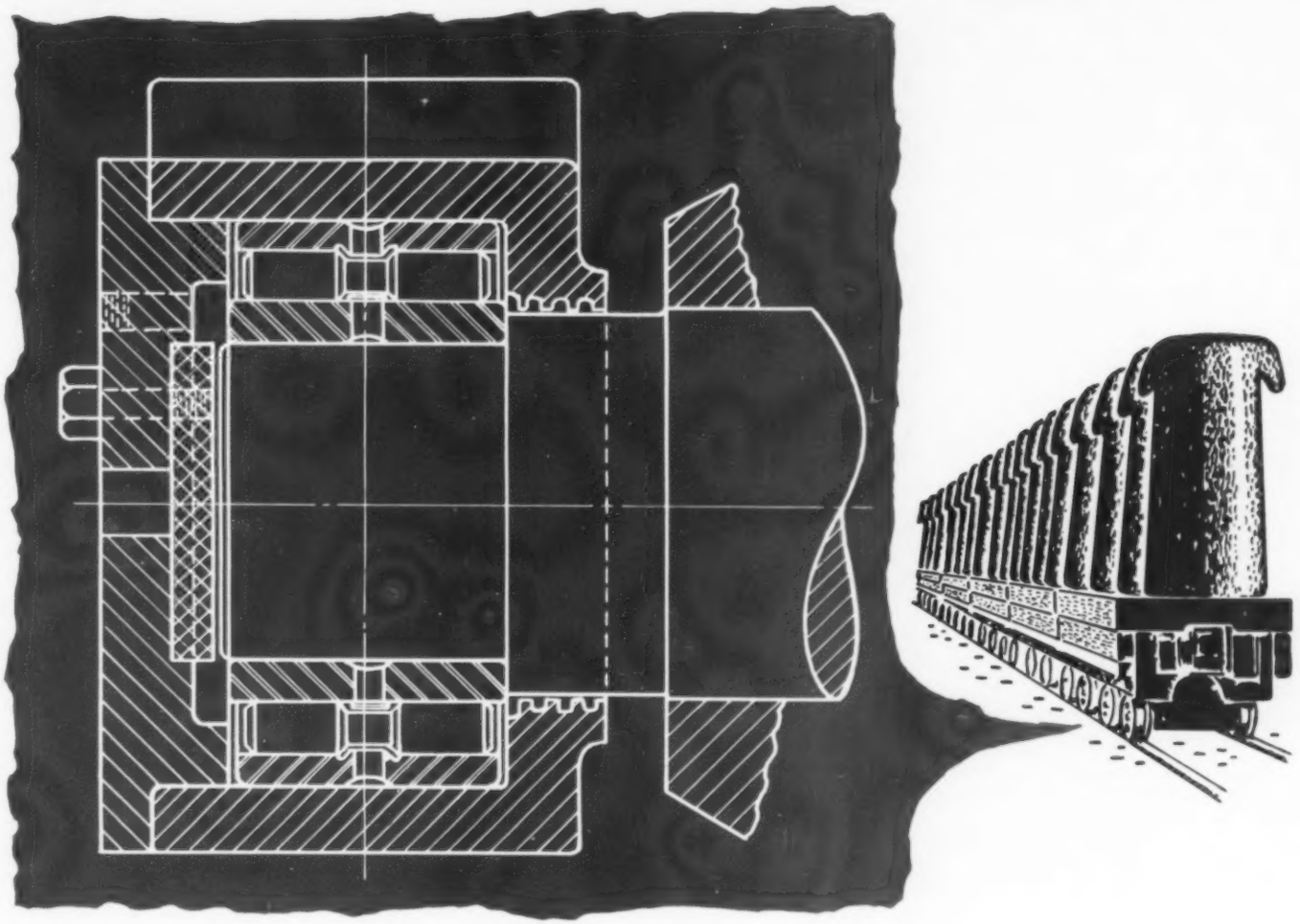

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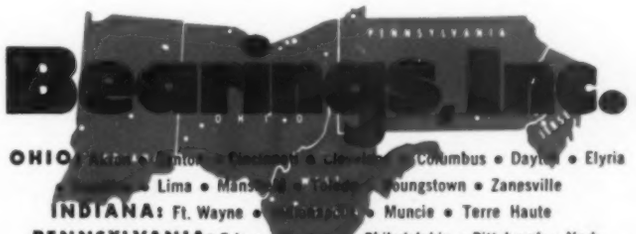

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Peabody burners (three in each boiler) use a common pilot flame to ignite both the coke oven gas and the emergency hot residual tar fuels. The latter is steam atomized and burned according to standard oil burning techniques. As the combustion control diagram (Figure 2) shows, there is a separate supply of pilot gas so that hot tar may be burned without reference to the supply of coke oven gas, if required. Up to the moment of writing it has not been necessary to burn the hot tar.

Precise savings in operation of the facility are difficult to estimate for a number of reasons, chiefly because much of the coke oven gas was formerly flared off or bled to the atmosphere. Major advantages thus far, however, have proved to be the steadier supply of process and heating steam and improved efficiency of the associated old coke breeze-fired boiler house.

Duality of supplies, valving, etc., was carried as far as possible to eliminate shut downs due to purely maintenance operations. The looped steam supply, for example, permits operation of all turbines by an auxiliary header while maintenance work is being performed on the main header. Manually operated isolation valves, not shown in the diagram, permit replacement or repair of the main valves connecting each boiler to the header without interfering with steam generation by the other boilers. Continuous supply of instrument air is assured by an electrical auxiliary compressor which operates whenever plant air falls below a safe margin. Arrangement of the control panels permits emergency operation by one man if the other member of the normal operating crew is incapacitated. There is also a standby mechanical feedwater control.

Basic objective of the design team was to create a facility which would integrate with the existing equipment in the coke breeze-fired boiler house and make maximum use of the waste fuels produced by the by-product plant. It was felt that a facility designed to augment or replace an existing facility should be as automatic as possible while incorporating maximum safeguards against avoidable shutdowns of a character which would defeat the purpose of the installation.

Heating system for the 900-ft hot tar supply line is electrical, based upon the impedance offered by the 3-in. steel pipe to the passage of a 24-volt alternating current. Designed by Fluid Systems, Inc., of New Haven, Conn., it offers several advantages in economy of construction and maintenance over the more conventional steam tracer pipe heating system. As already mentioned, the hot tar has not yet been required as makeup fuel. Aside from a relatively small compressor station at the by-product plant proper, however, there are no storage facilities for excess coke oven gas, and it is possible that the residual tar may be required as fuel in the event of any major difficulty with the coke breeze-fired boiler house. Merely turning on the current will raise the temperature of the tar pipe to the required 250 F within a few hours. At ambient temperatures of between 0 and 100 F, the residual tar is a solid. At present much of this tar is burned in Hazelwood mills while the balance is carried across the river in special insulated tank cars for use in open hearth furnaces.

Overall dimensions of the facility are 75-ft square by 40-ft high. It adjoins the ammonium sulphate plant and is within 50 ft of the coke breeze-fired boiler house. Total cost is estimated at $1,120,000.

GAGE CONTROLLED AUTOMATICALLY ON TANDEM COLD REDUCTION MILL

▲ AN X-ray gage system for closer, continuous control of cold reduction mills producing sheet and strip products has been developed through the cooperative efforts of the United States Steel Corp. and the General Electric Co. After adequate tests and experimentation, this system is now operating on No. 2 five-stand tandem cold reduction mill at U. S. Steel's Irvin Works at Dravosburg, near Pittsburgh, Pa.

This new installation is the first over-all thickness control in the steel industry to utilize not only a screwdown control to vary reduction on the first stand, but also a vernier system operating on the roll speed of the last stand. With this arrangement, thickness variations in the finished product can be held within 0.00015 in. smaller than was ever possible by manual means.

A unique feature of the regulating system is that it is completely free of vacuum tubes and was designed on the basis of transistor and magnetic-amplifier techniques and components.

Control of the No. 1 stand screwdown originates in an X-ray gage between stands No. 1 and No. 2. The gage is suspended from a retractable carriage with the X-ray unit below the strip and the detector unit above the strip. The desired thickness of the steel sheet to be cold reduced is set on a dial of the gage to select a reference signal. The actual thickness of the steel is then measured by the X-ray gage and the difference from the desired thickness is brought to the automatic control panel in the form of an electrical signal. This signal activates a transistor discriminator in the automatic control which observes the direction of the error, whether heavy or light, and also the degree of error.

The discriminator emits a polarized d-c signal which is fed into an on-and-off time circuit containing magnetic amplifiers. On-timing is a function of the magnitude of the de-

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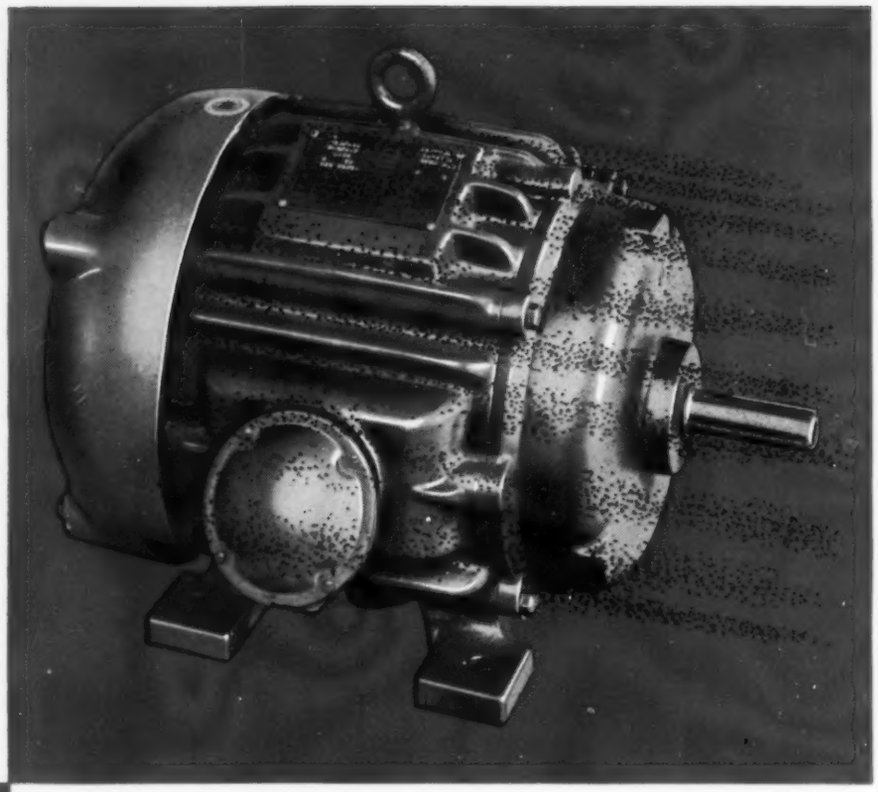

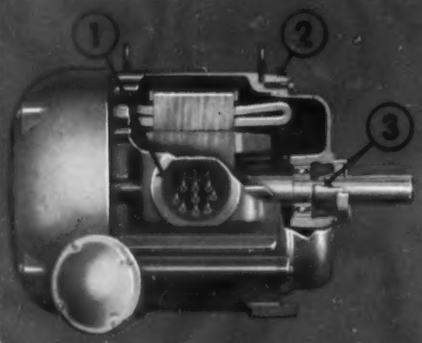

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TURBINE-GENERATORS TURBINES MOTORS GENERATORS DEAERATING HEATERS EJECTORS CONDENSERS COMPRESSORS TURBOCHARGERS TUBE CLEANERS STRAINERS

Figure 1 — At U. S. Steel Corp.'s Irvin Works, an employee watches an X-ray thickness gage dial for variances beyond specified tolerances for fast-moving strip steel on five-stand tandem mill in background. The X-ray unit is part of an automatic gage control system which was developed jointly through the cooperative efforts of both companies.

viation signal available. If the steel leaving stand No. 1 is 0.0005 in. off-gage, the screwdown motors will run for a shorter time than if the steel is 0.0007 in. off-gage. This permits the screwdowns to run less frequently to bring the strip or sheet within tolerance than if a constant on-time were provided.

The off-time circuit is provided to permit the steel to travel from the rolls of stand No. 1 to the X-ray gage position before the regulator activates any further operation of the screwdowns. As the strip speed varies over a wide range, the off-timing must vary inversely with the strip speed. The deviation signal, after being modified by the on- and off-time circuits, operates the up and down relays of the No. 1 stand screwdown motors. The screwdown motors run in the required direction to correct the steel thickness and to maintain within close tolerances the desired thickness of strip leaving the first stand.

Several auxiliary functions are incorporated in the No. 1 screwdown regulator, such as "screw reset," "screw departure indication" and "screw departure limits." The major part of the off-gage steel supplied to a cold reduction mill is off-gage toward the head and tail ends of the strip. The screw-reset function is provided to return screws to normal position at the end of each coil or at the discretion of the operator to cause special treatment of strip thickness at thread speed. This allows the mill to attain on-gage product earlier in the threading operation to improve results at the beginning of the coil.

The screw departure indicator shows the operator how far the screws have departed from his original selected position. There may be times when the automatic control would tend to run the rolls either too far apart or too close together and cause improper rolling. The screw departure limit circuit prevents this misoperation since it disconnects the automatic control when preselected limits are reached. At the same time, indicating lights on the control panel inform the operator his control is off automatic operation.

Another auxiliary function of this control is incorporated in the regulator inspection. If the regulator does not reduce any thickness error within a preselected time, it is removed from operation. This function prevents misoperation of the screwdown controls caused by malfunctioning of any of the components of the equipment.

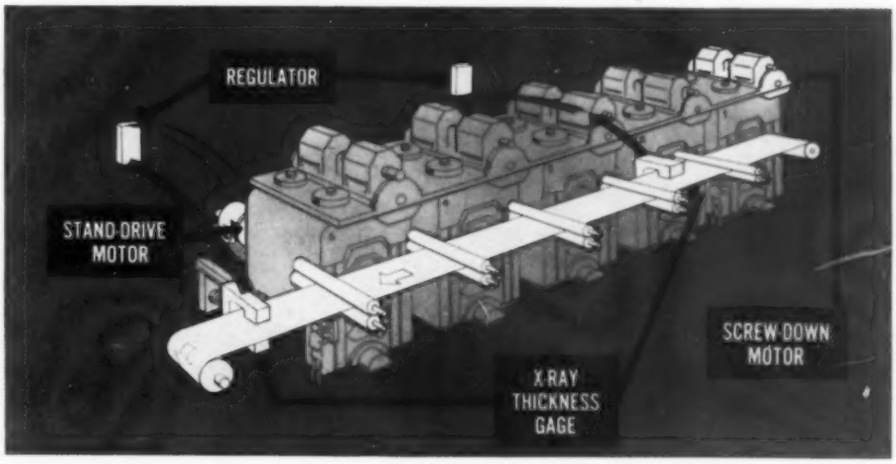
The operation of the X-ray gage control system on stand No. 1 screwdowns reduces large thickness variations to small variations. The small variations are further reduced by the operation of the product thickness regulator on stand No. 5.

The stand No. 5 mill motor in this installation receives its power from a common source which is supplying power also to the other stands of the drive. The motor field has a current regulator consisting of an exciter and an amplidyne with both coarse and vernier rheostats controlling the excitation. Therefore, speed of the fifth stand can be controlled in relation to previous stand motor speeds and thus adjust the thickness of material leaving stand No. 5 by varying the tension between stands No. 4 and No. 5.

An X-ray gage similar to the one used between stands No. 1 and No. 2 measures the thickness of the strip leaving stand No. 5 and being wound on the reel. Here again the desired thickness is set on a dial of the X-ray gage as a reference signal. This is compared with the thickness of the steel leaving stand No. 5 and a signal proportional to the difference is fed into the automatic control as a deviation signal. This signal is again fed into a transistor discriminator which observes direction and amplitude of the signal. The polarized signal from the discriminator is increased by a transistor amplifier to a power level suitable for the field current regulator.

In actual operation, stand No. 5 is set up manually by the operators by means of the screwdowns. The coarse and vernier settings of the motor-field current regulator of the gage system are then set to approximately the desired output thickness. The automatic control system then operates over a range of plus or minus five per cent speed to control product thickness to the desired value. Changing the speed of stand No. 5 in relation to that of stand No. 4

Figure 2 — Two X-ray thickness gages are used on this 5-stand tandem cold strip mill, one gage located between stands No. 1 and 2 is used for coarse control, and another gage after stand No. 5 is used for vernier control.



changes the draft and tension on the strip between these stands and thus controls the thickness of the delivered steel. The control system is continuously in control of product thickness and makes corrections for very small deviations.

On stand No. 5 as on No. 1, several auxiliary functions are incorporated in the regulator. Since the regulator has a limited range, provision is made to indicate to the operator of stand No. 5 when the regulator is out of range, requiring manual adjustments of the screw settings or of the vernier speed controls. A regulator operating-range indicator mounted on the operator's cabinet is calibrated minus 5 per cent to plus 5 per cent speed departure. As long as the meter indicates within this range, the automatic control will regulate. However, if the meter indicator swings to one end of the scale, a regulator-limit indicating light signals the operator that the regulator is out of range and manual adjustments must be made on the stand No. 5 controls. A regulator inspection function as described for stand No. 1 protects the mill in case of failure of any of the system's components.

This new X-ray gage control is designed not only to provide a better product for the consumer and minimize waste due to off-gage material, but to augment the skill, experience and knowledge of the roller and to relieve crew members of the monotonous and exacting chore of continuously adjusting manual controls. It allows the crew to direct their attention to the other important functions in the operation of the cold reduction mill.

New Metals Plant Answers Need for New Alloys

▲ A metal pilot plant designed to bridge the gap between laboratory and commercial production of new alloys and processes has been opened by the Westinghouse Electric Corp. at Blairsville, Pa. The $6,000,000-facility combines under one roof virtually all types of metal processing equipment.

Created to be the final link in Westinghouse's rapidly expanding metallurgical development facilities, the 173,000 sq ft plant will help provide the new and better alloys that product design engineers are now demanding. The plant is designed to process both wrought and cast alloys with equipment flexible enough and large enough to permit actual manufacturing conditions. In this way, the Blairsville plant is more than a pilot plant, and its moderate production output will uncover problems that can only be found under actual manufacturing conditions.

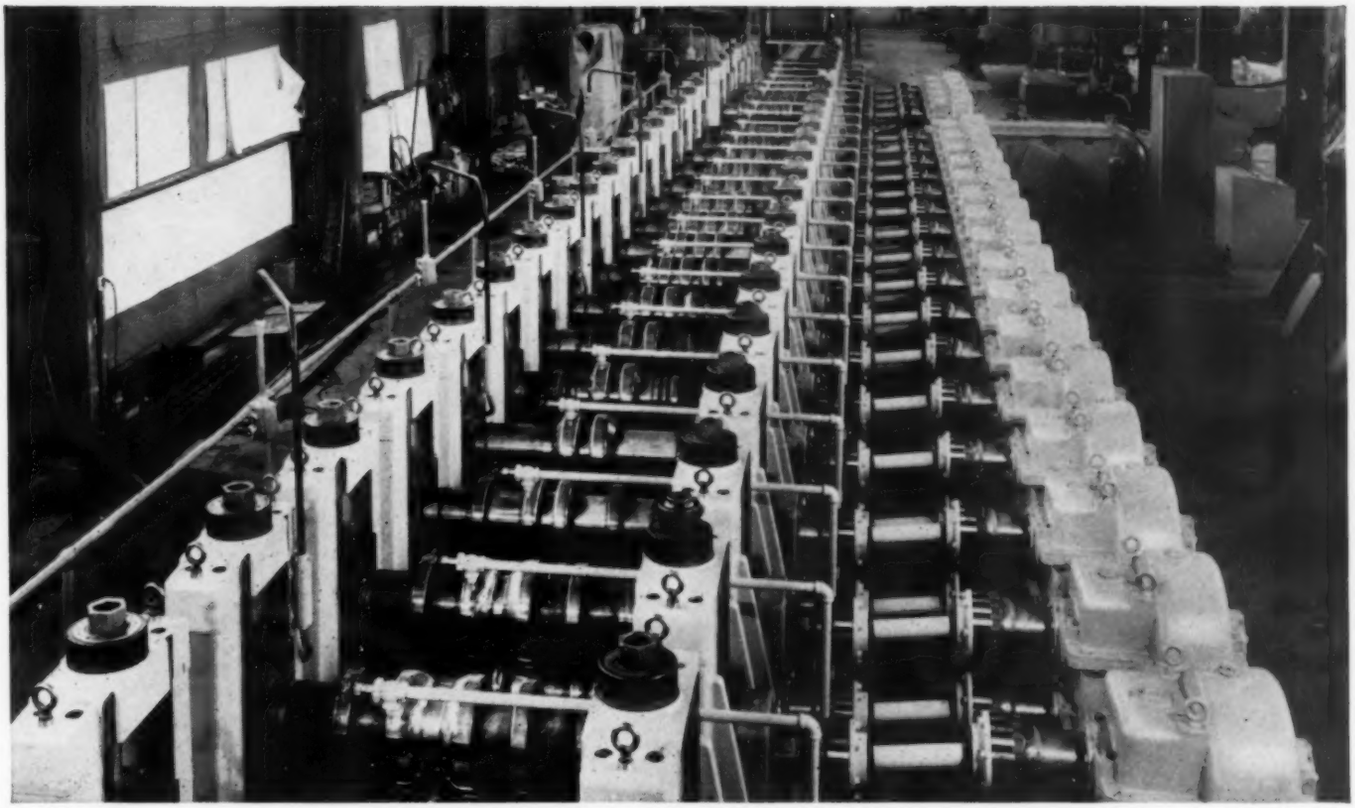
Need for the plant became apparent several years ago when it was recognized that the key to advanced design in steam and gas turbines, generators, transformers, nuclear power reactors, etc., was the development of new metals having better temperature, strength, and magnetic characteristics. New titanium, molybdenum, expansion, and resistance alloys show particular promise.

As important as the alloys themselves is the need for practical commercial processes to manufacture these alloys into finished products. With this in mind, a large portion of Blairsville is concerned with processing techniques such as forging, hot and cold rolling, heat treating, shell mold and investment casting, and powdered metallurgy.

The equipment for the plant, stresses flexibility and multipurpose usefulness. As an example, the induction vacuum melting installation can accommodate heats ranging from 300 to 2000 lb. This installation can be used for vacuum casting of large ingots as well as low temperature vacuum annealing of titanium.

Equipment in the Blairsville plant is larger than that found in most pilot

Figure 1 — Aerial view of the Blairsville plant showing relative heights of high and low bay areas. Office and laboratory areas are in low addition in the foreground. Possible future expansion will be in the direction of the parking lot.



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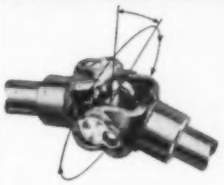
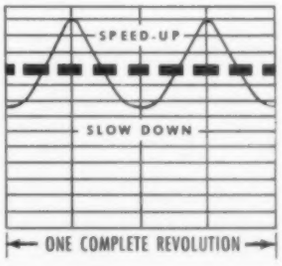


During rotation at a given angle, pin or slipper-type joint speeds up, slows down twice during one revolution.

Solid line shows speed variation for one revolution of pin or slipper-type joint at a critical angle. Note constant velocity of 100% for Rzeppa Joint (dotted line).



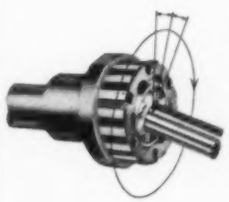


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Figure 2 — A charge is poured from a 3000-lb induction air melting furnace to be used in making ingots. A 4-ton jib crane tilts the furnace while the overhead crane supports the ladle.

plants permitting the manufacture of specialty metal products at competitive costs, thus allowing reasonable loading of tools that normally cannot be loaded fully on development work. This operating policy not only lowers the cost of development work but also provides trained operating crews for all equipment.

The plant is situated on a 540-acre tract 40 miles east of Pittsburgh and has been designed to make possible future expansions easy. Room is included within the present facilities for the manufacturing of nuclear reactor fuel elements.

Included in the plant, believed to be the largest pilot plant of its type in the country, is an 18,000-lb and three smaller forge hammers; a 1000-ton steam-hydraulic forge press; seven forge furnaces; three induction melting furnaces varying in size up to 5000 lb; a cold hearth furnace; a 1000-hp reversing, hot-rolling mill; a 500-hp reversing, cold-rolling mill; bell type and roller rail box type electric furnaces; a shot pouring facility; shell mold and lost wax investment casting facilities; arc furnaces; and other equipment. Rolling mills are described in more detail in following article.

Because of the electrical industry's dependence upon metals with special mechanical and electrical properties, Westinghouse has long been a pioneer in the development of special alloys. High on the list of Blairsville projects is further development of these alloys, including Discaloy, Refractaloy, K-42-B, Hipernik, Hiperco, Hipersil, and Kovar.

The first three on the list are high temperature alloys for application in gas and steam turbines. Here, rotors

Figure 3 — This induction vacuum melting installation can accommodate heats ranging from 300 to 2000 lb. The installation can be used for vacuum casting of large ingots as well as low temperature vacuum annealing of titanium. Roughing and final pumps will lower pressure to 10 microns.

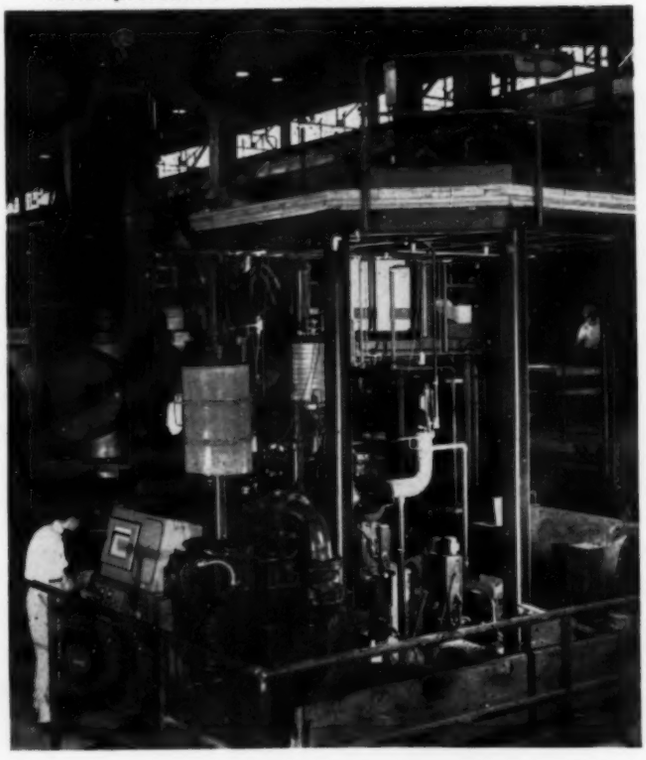


Figure 4 — The 18,000-lb forge hammer is seen descending on an ingot held by a manipulator. The hammer is especially designed for both open and closed die work. Workman is holding a hard steel gage which limits the hammer's travel.

and blades must withstand stresses at extremely high temperatures and also resist corrosion and remain ductile. Hipernik, Hiperco, and Hipersil are magnetic alloys used in saturable reactors, magnetic amplifiers and choke coils. Kovar is an expansion alloy used where an airtight seal between gas and metal is required, as in electronic tubes, glass bulb rectifiers and X-ray tubes.

Explaining the importance of these new alloys, Mr. Trigg pointed out that 20 years ago steam turbines were being built to operate with steam temperatures of about 800 degrees F and pressures of about 1200 psi. New units now are being designed for 1200 degrees and up to 4000 psi pressure. To make these advances, new alloys were required. And to go any higher in the temperature and pressure scale will require still better alloys. That is what Blairsville hopes to provide.

The plant was designed by the Westinghouse East Pittsburgh Works Engineering Department. Contractors were: Navarro Corp., general; Patterson-Emerson-Comstock, Inc., electrical; and Limbach and Co., mechanical. All are from Pittsburgh. The F. H. McGraw and Co. of New York did the equipment erection and installation work including all piping and electrical installations.

Specialty Rolling Mills have Versatile Control

By A. J. WINCHESTER
Industry Engineering Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.
and
D. E. ABELL
Motor and Control Div.
Westinghouse Electric Corp.
Buffalo, N. Y.

. . . . important in the new metals plant at Blairsville are the specialty rolling mills . . . . these mills are large enough to provide moderate production output . . . . thus the research and development costs are reduced, crews are trained and the available supply of the rarer new metals is increased . . . .

▲ A reversing hot mill and a reversible cold mill with unique control equipment are now in operation at the new Westinghouse Metals Plant, just opened in Blairsville, Pa., some 40 miles from Pittsburgh.

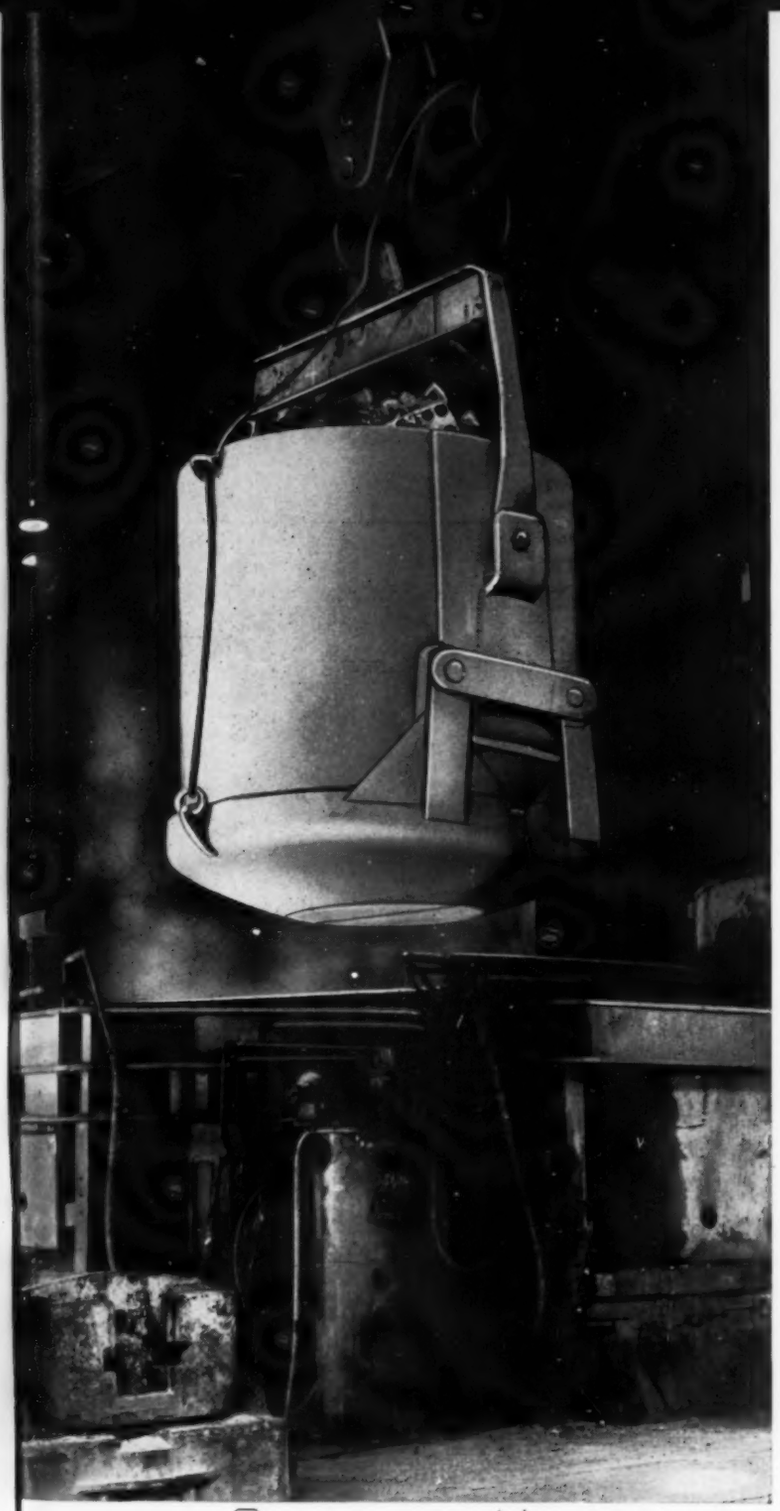
Like the entire plant, the hot mill and the cold mill are intended primarily for Westinghouse development projects, but their capacity is adequate for a certain amount of production rolling for use outside the company. Westinghouse acted to acquire its own facilities to ensure ready availability of the new and special alloys continually necessary for the development and improvement of the company's products.

The hot mill shown in Figure 1 is designed to handle 2000-lb ingots, slabs, or coils at a top speed of 400 fpm. The installation is complete with two slab heating furnaces, a 40-ft roller hearth furnace, two furnace coilers, mill approach and delivery tables, shear, and up-coiler. The four-high mill will handle slabs or strips up to 18 in. wide.

The four-high cold mill shown in Figure 2 has a top speed of 800 fpm and will also handle strip up to 18 in. wide. The left and right reels will take up to 3000-lb coils. The E. W. Bliss Co., Salem, Ohio, supplied both mills.

Main and auxiliary drive arrangements for the hot and cold mills, shown in Figure 3, use the same generators to energize the mill and reel motors for both mills. There are two reel generators and one mill generator, with the mill generator energizing the edger motor in addition to the mill motor for hot mill operation. This dual use of equipment, which permits substantial savings, is possible because the mills are part of a development facility, and it is not necessary to operate them simultaneously. The hot mill table motors are all AISE standard totally-enclosed, non-ventilated mill motors.

The control equipment for these mills is unique in that the same generator and the same regulating equipment are used for both the hot and cold mills. In addition, the hot mill has two modes of operation; as a blooming or slabbing mill, and as a reversing hot strip mill. Also, provision is included for turning all the



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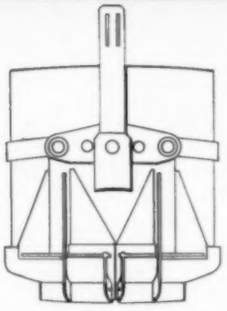

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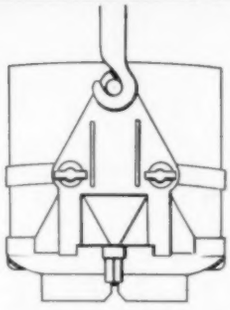

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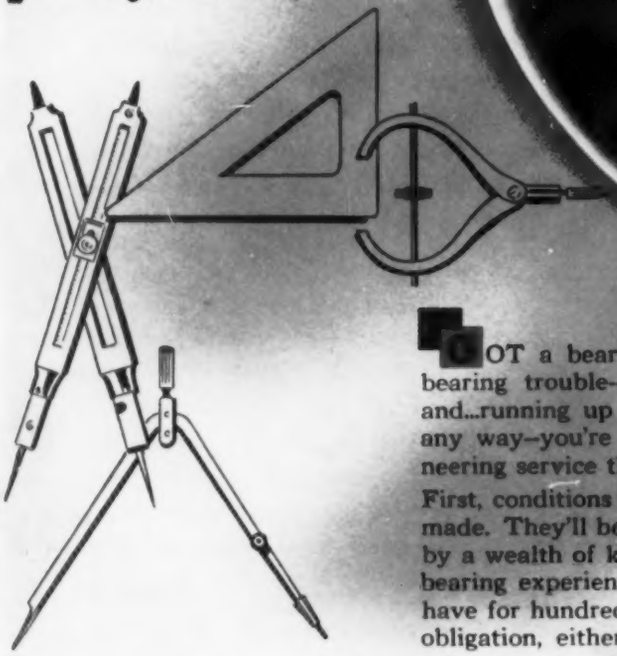

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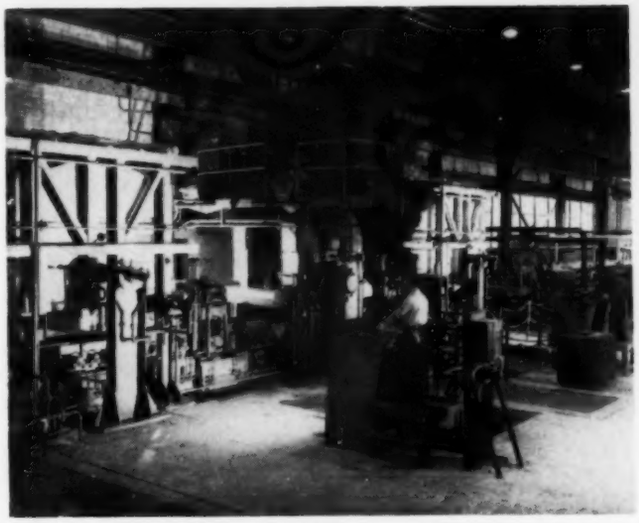


Figure 1 — A 1000-hp, 350/700-rpm, 600-volt, d-c motor drives the four-high hot mill which has a top speed of 400 fpm. Mill has 12 to 18-in. work and 32-in. back-up rolls. The operator's desk on the left and the roller's desk on the right side of the mill are positioned to give maximum visibility of the strip as it enters the furnace coilers.

Figure 2 — A 500-hp, 350/700-rpm, 600-volt d-c motor drives the four-high cold mill back-up rolls at a top speed of 800 fpm. Each reel is driven by a 300-hp, 400/1200-rpm, 250-volt, d-c motor. The mill has 8-in. work and 28-in. back-up rolls and will take strip up to 18 in. wide.

hot mill rolls which receive furnace heat when the cold mill is in operation. This permits cold mill operation during the long periods required for heating and cooling the furnaces, and requires more versatile control than for a conventional installation where a single set of generating and control equipment is used for one mill.

Because the hot mill must roll a wide variety of products, a highly flexible arrangement permits the mill to operate as a blooming mill, a slabbing mill, and a reversing hot strip mill. Since the temperature range in which some of the special alloys can be rolled is limited, fast reversal is necessary for blooming and slabbing operations for which the furnace coilers cannot be used.

The general arrangement of the mills is shown in Figure 3, although there are two slab heating furnaces at the entry end of the mill which are not shown. All of the tables, including the roller hearth furnace table, have adjustable voltage drives.

There are two furnace coilers, one on each side of the mill. When the bar is reduced in thickness to ½-in. or less, it can be deflected up into the coiler and wound under tension into a tight coil as it is delivered from the mill. On the next pass, the strip is then unwound from one furnace coiler, passed back through the mill, and coiled in the other furnace coiler. On the final pass the strip is then delivered flat over the runout table to the finished strip up-coiler. The furnace coilers are mandrel type with a slot for securing the end of the strip. This is accomplished by entering the end of the strip with the coiler at rest, and then accelerating the mandrel rapidly to take up the loop and bring the strip under tension before the end of the first revolution of the coiler mandrel. Each coiler drive has a limit switch to reset the mandrel with the slot in position to enter the strip on the next pass. To prevent damage to the equipment, a furnace mandrel is never stopped except for brief intervals when the furnace is hot. The mill runs at reduced speed when the strip enters the furnace coiler, but the usual practice is to accelerate the mill as soon as the strip is secured to the coiler mandrel.

Between the mill and each furnace coiler there is a pair of pinch rolls. The bottom roll is in line with the table rolls and is motor driven, while the top roll is driven only by contact with the strip. It is moved vertically by means of solenoid-valve controlled air cylinders to pinch the strip between the top and bottom rolls, or separate the rolls and establish the pass line to the mill when coiling or uncoiling. The pinch rolls normally serve two major purposes: to enter the end into the mill at the beginning of each alternate pass by gripping the strip and pulling it from the coiler, and to establish the pass line of the strip entering and leaving the mill when coiling or uncoiling in the adjacent furnace coiler. Under abnormal conditions the pinch rolls are used to pull out cobbles either from the mill or from the coiler.

On each furnace coiler a deflector roll is mounted at the point where the strip enters the coiler enclosure. Since this roll is exposed to furnace heat, it is necessary to keep it rotating except for brief intervals.

The roller hearth furnace is used principally for reheating slabs, but also may be used as a primary heating furnace. The roller hearth furnace table drive is synchronized with other tables so that the plate may extend into the furnace during normal operation without cobbling. When a plate is held in the furnace, it is oscillated slowly back and forth between the ends of the furnace with reversal initiated by a limit switch at each end of the furnace.

A vertical edger is mounted adjacent to the left furnace coiler on the up-coiler side. The three roll up-coiler for finished strip is at the end of the runout table.

For blooming and slabbing operation, the hot mill control is designed to obtain fast reversal of the mill and edger main drive motors. When the mill is accelerated from zero to top speed, the motor remains at full field strength until base speed is reached; generator voltage remains constant and motor field strength is varied between base and top speed. Mill gen-

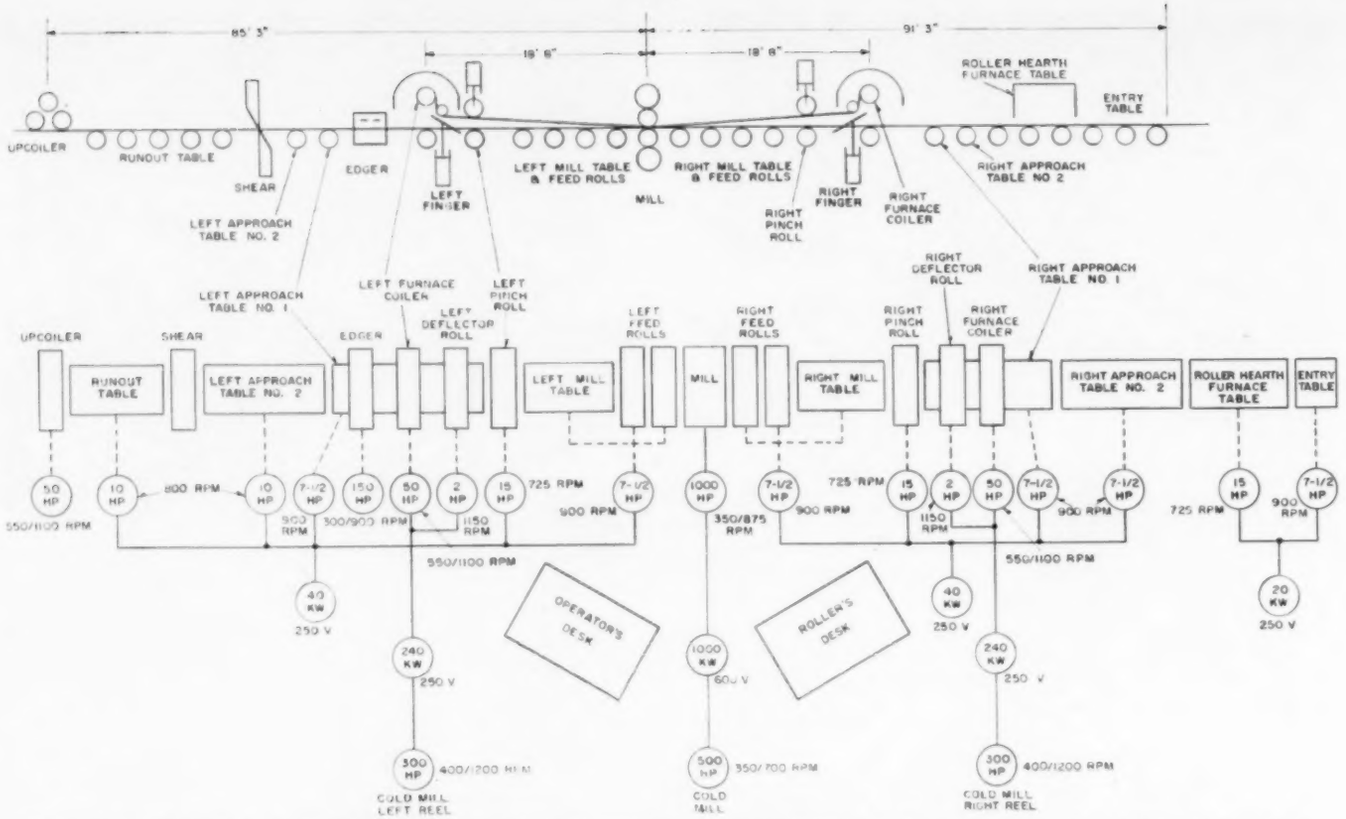


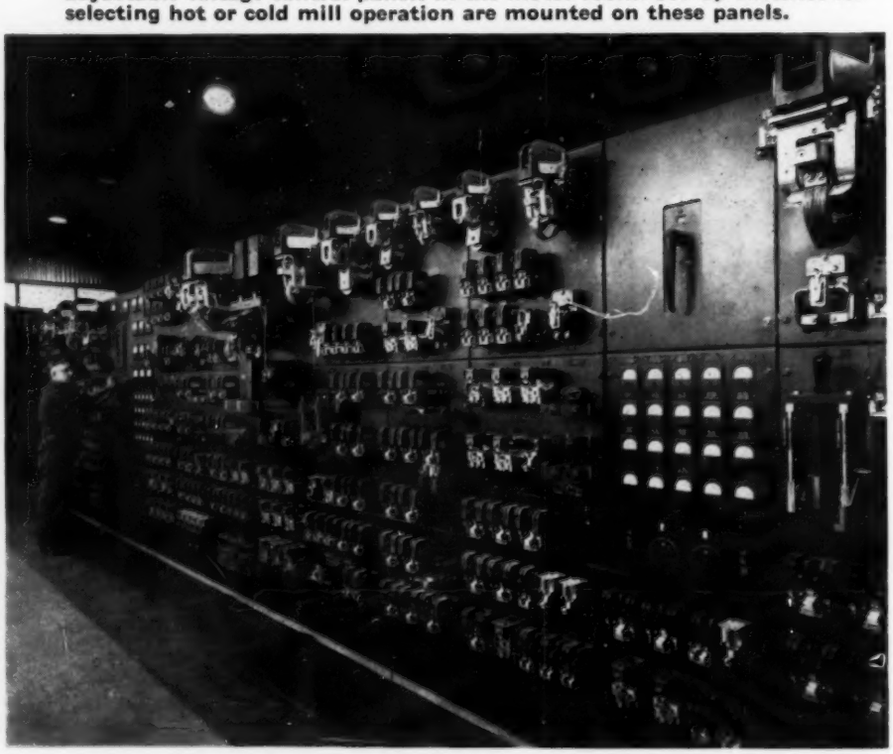
Figure 3 — Complete hot and cold rolling facilities are now in operation at the Westinghouse Blairsville metals plant. The same generating equipment is used for both mills. Transfer of control is accomplished by knife switches and selector switches in the motor room.

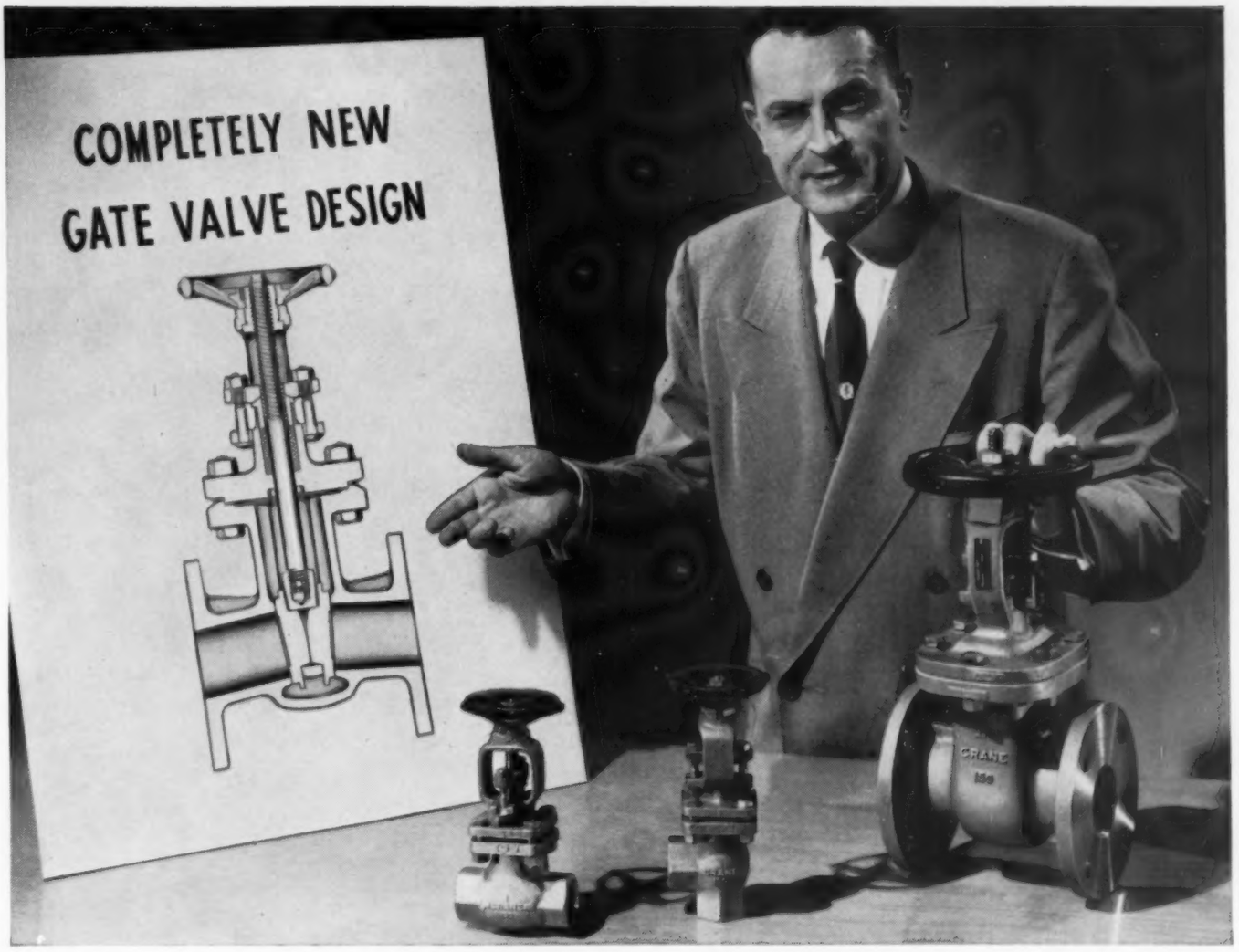
erator and the main drive and edger motor field strength are regulated. Rapid reversal is obtained by using regulating systems capable of high forcing. Exciters are provided for the mill motor and generator and are energized by rotating regulators. In case of excessive load with the mill and edger motors at reduced field strength, the regulating system automatically limits load by strengthening the field of the motor which is overloaded. The adjustable voltage control panels are shown in Figure 4.

When either or both of the furnace coilers are used, reversal time is increased so that tension between the mill and the reels is maintained during acceleration and deceleration. Rate of mill acceleration and deceleration is governed by travel time of a motor-operated rheostat. Mill speed is determined by the setting of a combination motor-operated rheostat which has one circuit which varies mill generator field strength, and another circuit which varies mill motor field strength. The first portion of rheostat travel varies mill generator voltage from zero to 600 volts, and the last portion varies mill motor speed from base to top speed.

Strip tension between the reels and the mill is regulated by rotating regulators. Each reel generator is controlled by a rotating regulator which regulates the constant reel armature current; the magnitude of this current is adjusted by means of a rheostat on the operator's control desk. Each reel motor is excited by a rotating regulator which regulates for a

Figure 4 — Checking of equipment performance is simplified by a complete set of instruments for all main machine and regulator circuits on the adjustable voltage control panels in the motor room. Set-up switches for selecting hot or cold mill operation are mounted on these panels.





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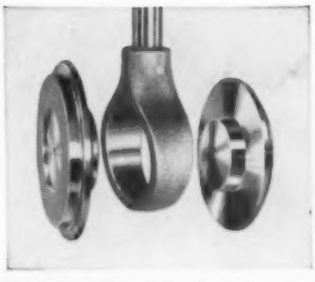

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reel motor emf proportional to mill speed; this varies reel motor field strength in proportion to coil diameter. Intelligence indicating strip speed is supplied by a pilot generator connected to the mill motor. The combination of constant armature current and variation of motor field strength in proportion to coil diameter gives constant tension at all mill speeds and coil diameters. The regulating system limits speed of the reel motors during threading and in case of strip breakage. Inertia compensation is provided to maintain tension when the mill is accelerated and decelerated.

The control is designed to maintain a top strip speed for the hot mill of 400 fpm regardless of mill roll diameter, which can vary from 12 in. to 18 in. This is accomplished by roll diameter compensating rheostats, making it easier to match the coiler, edger, and table speeds with strip speed.

Transfer of the control to the hot or the cold mill is accomplished by knife switches and selector switches in the motor room. The same regulating systems are used for each mill for the mill generator, the mill motor, the reel generators, and the reel motors. The same motor-operated rheostat is used for setting mill speed and for controlling rate of acceleration and deceleration. The functional operation of the regulating systems is identical for each mill except that for the cold mill motor, current limit is not required and is not provided.

A dual screwdown drive is provided on the hot mill to give the high screw speed required for slabbing and the slow speed required for strip mill operation. The drive is adjustable voltage and consists of two 15-hp, 725-rpm mill motors for high speed; two 35-hp, 575-rpm mill motors for slow speed; and two 35-kw, 250-volt generators which can operate at double voltage with light load. The 35-hp slow-speed motors are mechanically disconnected by means of clutches for high-speed operation. Each generator is electrically connected to only one motor at a time. A current-limit circuit limits current by decreasing generator voltage if the load is excessive. The generators are part of the auxiliary motor-generator set shown in Figure 5.

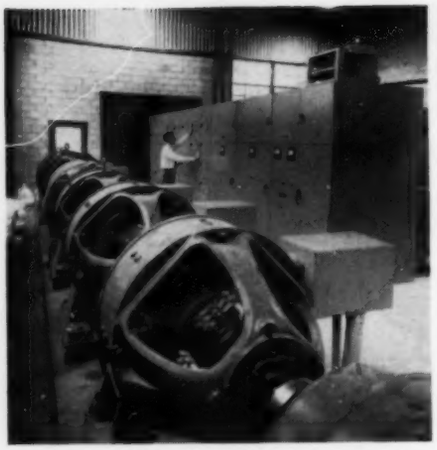

Figure 5 — A ten-unit motor-generator set provides adjustable voltage for the hot mill tables and screwdown, variable potential excitation for the hot mill main drive motor, edger motor, and mill generator, constant potential excitation, and 250-volt d-c supply for constant voltage auxiliaries. The control center for 440-volt a-c auxiliaries is mounted adjacent to 4160-volt fused combination linestarters for the 1500-hp main motor-generator set synchronous motor, 350-hp auxiliary motor-generator set squirrel-cage induction motor, and 400-hp descaling system pump squirrel-cage induction motor.

Each of the adjustable voltage auxiliary generators has a rotating voltage regulator with individual current limit for each motor which the generator supplies. This gives more protection to the armature circuit of each motor than provided by current-limit schemes previously used. The difference is that the new scheme protects each motor armature, while the old scheme protects the generator by limiting generator armature current but does not protect each motor when two or more motor armatures are connected to one generator.

The operator has the choice of having the tables, feed rolls, and pinch rolls automatically synchronized with the mill or under separate control from master switches, one for the rolls on the left side and one for the rolls on the right side of the mill. By means of a set-up switch, the operator may select which tables are to run with either automatic synchronizing with the mill or under master switch control.

This installation provides versatile large-scale rolling facilities with limited production capacity at a moderate capital cost, an ideal arrangement for development and pilot plant operation.

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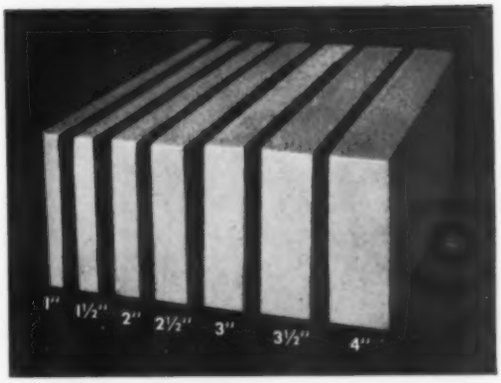

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This modernization program, along with a planned preventive maintenance program which is now being put into effect, is expected to raise the KW capacity of these plants from 20 megawatts to 30 within the next few months.

The Cities Service Heat Prover has played a major role in this improvement program. It is used extensively to examine combustion conditions in the furnaces, check station instruments, and guard against air infiltration through boiler settings and duct work, thus enabling plant personnel to operate the equipment constantly at design efficiencies or better.

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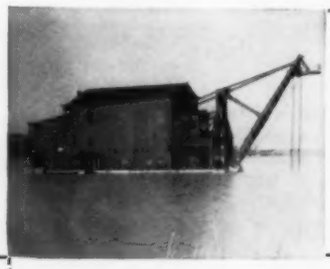

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▲ A barrier to high and profitable output of modern strip rolling mills is the down-time required for changing the mill rolls. Crucible Steel Co. of Midland, Pa., has found that it can cut this profit-eating down-time to a minimum with the aid of a unique hose coupling manufactured by Titeflex Inc., of Springfield, Mass.

Because of the high finish required and other factors, Crucible found that the work rolls in its 56-in. four-high reducing mill (Figure 1) generally had to be changed about twice in every 8-hour shift.

To keep the down-time loss from such frequent shutdowns reduced to a minimum, replacement rolls are kept in reserve alongside each mill (Figure 2), the mills are designed to make roll change as rapid as possible; and mill crews become expert at removing one massive, highly finished, easily marred roll and replacing it with another in a remarkably short time. However, one difficulty often bogs down the whole operation—the coupling and uncoupling of fluid lines connected to the rolls. To permit rapid roll change the roll bearing blocks (chucks) are keyed into place (Figure 3), and both the roll and its bearing blocks are removed or installed as a unit.

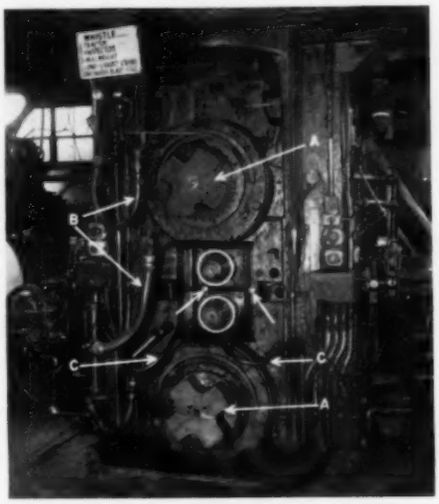


Figure 1 — End view, 56-in. single stand four-high reducing mill at Midland plant of Crucible Steel Co. Arrows (A,A) are ends of heavy back-up rolls, smaller, splined shafts (circles) are ends of work rolls. Note heavy fluid lines (B,B) which feed large flow of lubricant to cool and lubricate back-up roll bearings. Also, note hydraulic lines (C,C) which supply high pressure fluid to lifting jacks (arrows) for raising upper set of rolls.

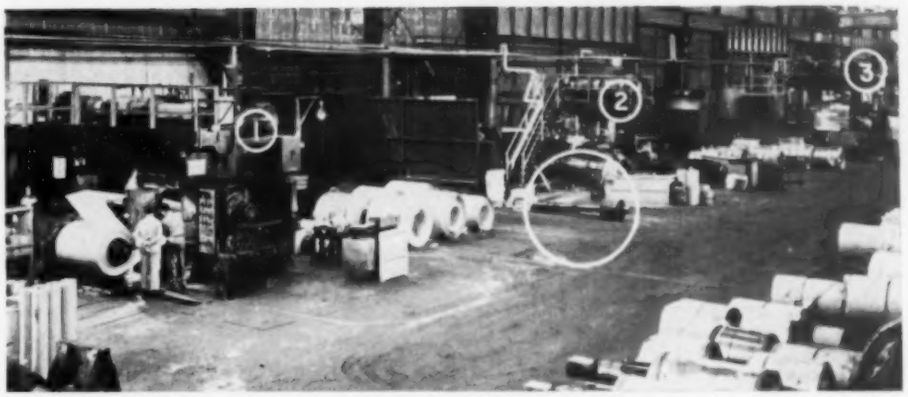


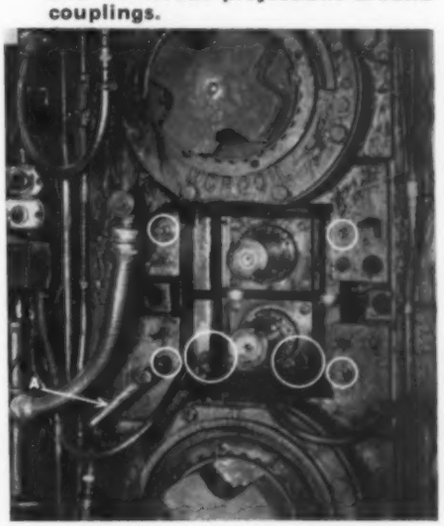
Figure 2 — Steel sheet rolling mills at Midland, Pa. plant of Crucible Steel are: 1, at left, two-high temper mill; 2, center, a 26-in. four-high reduction mill; and 3, right, a 56-in. four-high reduction mill. Note mill rolls, lower center, stored close to mill for rapid roll changing.

Fluid lines connect to the mill rolls for two reasons: 1. to provide a heavy flow of lubricant to both cool and lubricate the large bearings of the back-up rolls (Figure 1), which bearings heat up rapidly because they bear the brunt of the heavy loads imposed by the high rolling pressures; and 2. to feed high pressure hydraulic fluid into hydraulic lifting jacks (Figure 1) which raise the upper set of rolls whenever a large clearance between work rolls is needed (as when feeding a new strip into the mill, etc.).

The fluid lines connect to pipe fittings projecting from the bearing blocks. In the mills used by Crucible at its Midland plant (manufactured by United Engineering and Foundry Co.), these fluid lines were originally connected to the roll blocks by threaded fittings (unions), which had to be disconnected every time a roll was removed and had to be reconnected when a new roll was installed. This proved to be the bottleneck in the roll changing operation because the cramped space and surrounding projections made the use of a wrench, to loosen or tighten these fittings, very difficult. This was especially the case with the fittings on the back ends of the rolls (Figure 4), which required men to work in the cramped space between the mill stand and the wall. Furthermore, the hydraulic fluid lines for the lifting jacks carry oil at high pressure (850 psi), therefore the threaded fittings for these lines required extreme tightening to make them leakproof. Hence, despite good mill design and expert crews, the Crucible Co. found that this step alone—connecting and disconnecting the threaded pipe fittings—accounted for more down-time than the entire period (about 20 minutes) required by a skilled crew for the rest of the roll changing operation.

To solve the problem of eliminating this time loss, Crucible decided to use quick-connect and disconnect couplings in the fluid lines connecting

Figure 3 — Close-up of rolling mill shows quick-roll-change arrangement. Roll bearing blocks (chucks) are quickly released or locked in place by rotating release keys (small circles) with handle (A). Also, high pressure lines to hydraulic lifting jacks are quickly connected to or disconnected from roll chuck by Quick-Seal couplings (large circles). Note cramped space and numerous projections around couplings.



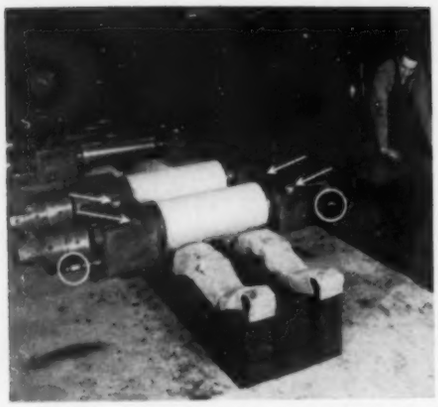


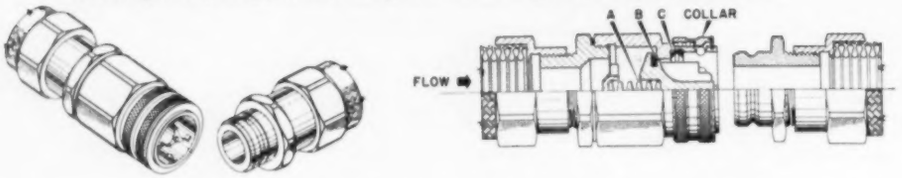
Figure 4 — Extracter is about to pick up a new lower work roll. Note the high pressure line fittings (circles) on both ends of roll, each with attached nipple of Quick-Seal coupling. Chucks of lower work roll (foreground) have hydraulic jacks (arrows) whereas chucks of new upper roll, alongside it, do not.

to the rolls. But the rolling mill service imposed severe practical requirements which called for these exceptional characteristics in the quick-connect coupling. In the first place, the coupling had to be leakproof the instant it was connected and had to remain leakproof under high pressure, to avoid the safety hazard of oil leakage. Furthermore, it was essential that the coupling permit full swiveling of the flexible hose about the stationary pipe fitting, to avoid hose twisting and eventual breakage. And finally, it was essential that the coupling have a rapid, simple connecting and disconnecting action, to make hydraulic line connecting and disconnecting fast and easy for the busy roll-changing crew.

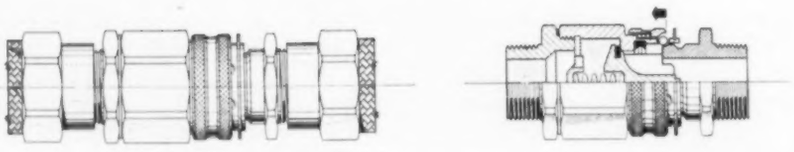
In the Quick-Seal coupling, Crucible found the desired combination of all these characteristics. The coupling has a ring seal which abuts against the nipple when the coupling is closed, thereby making a tight seal as soon as the coupling is connected. When fluid pressure is in the line it expands the lips of the seal, making the coupling leakproof at high pressures.

There is still a further important practical requirement for quick-connect couplings for rolling mill application. To avoid the time loss required for shutting off valves so as to close off the lines that are disconnected during roll changes, the coupling should have built-in check valves which snap close and thereby automatically close off both ends of each line the instant the coupling is opened. Such a coupling is made by Titeflex which provides all the above features of the Quick-Seal design and in addition includes a built-in check valve in each end of the coupling. As is clear from the cut-away illustrations of the operation of this coupling in Figure 5, the check valves are opened and permit full flow when the coupling is connected. Disconnecting the coupling automatically snaps the check valve closed in each part of the coupling, thus instantly closing both ends of the disconnected line.

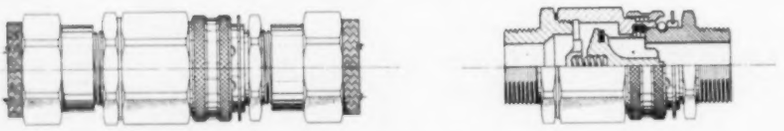
Figure 5 — Double check valve coupling has check valves in both nipple and body, which operate simultaneously as shown below for single check valve. Sketch A. Coupling is disconnected; spring-loaded check valve in coupling body keeps fluid line closed. Sketch B. First step in connecting coupling; retracting collar on coupling body lets nipple move in until its end seats against check-valve shoulder. Fluid line still closed by spring-loaded check valve. Sketch C. Second step in connecting coupling; strong push on nipple forces check valve back, opens valve, lets fluid flow through into nipple-end of line. Sketch D. Final step in connecting coupling; release of collar on coupling body pushes retainer balls into groove, locks both ends of coupling together. Nipple keeps check valve open, permits full fluid flow through line. Fluid pressure forces lips of seal ring apart, makes coupling leakproof at high pressure. Retainer balls in nipple groove keep both ends of coupling together but permit hose to swivel freely. This prevents hose kinking, and ultimate hose breakage. Also, full swiveling makes coupling connecting and disconnecting fast, easy, hence only a one-man job even for large hose.



Sketch A



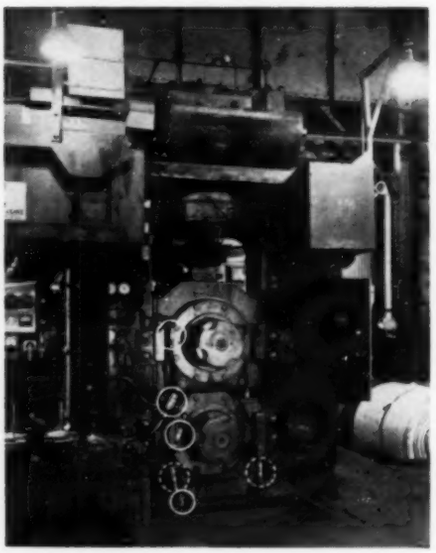
Sketch B



Sketch C

Sketch D

Figure 6 — Two-high temper mill close-up shows lifting jacks, which raise upper roll for roll changing, and coupling in fluid lines. Two upper full circles show lubrication lines for upper roll, equipped with Quick-Seal couplings. Two lower full circles show same couplings for lower rolls. Broken circles show double-check valve couplings in high pressure lines to lifting jacks.



CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, January 30, 1956 — Social Hour 6:30 P.M., Dinner 7:40 P.M.

"The New South," by Dr. J. L. Brakefield, Director of Public Relations, Liberty National Life Insurance Co., Birmingham, Ala.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, January 10, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

Maintenance Symposium —

"Selection of Lubricants," by Charles L. Pope, Eastman Kodak Co.

"Some Aspects of Selection of Bearings," by Kenneth E. McHenry, Assistant to Superintendent, Mechanical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

Hotel Sheraton, 715 Delaware Avenue, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, January 3, 1956 — Dinner 6:15 P.M., Meeting 7:45 P.M.

"Controlled Atmosphere in Heat Treating," by C. W. Sanzenbacher, Development Engineer, Surface Combustion Corp., Toledo, Ohio

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, January 24, 1956 — Dinner 6:00 P.M., Meeting 8:00 P.M.

"Some New Developments in Sintering," by Harold E. Rowen, General Manager, Dwight-Lloyd Div., McDowell Co., Inc., Cleveland, Ohio.

University Club, 3813 Euclid Avenue, Cleveland, Ohio

DETROIT SECTION

Tuesday, January 10, 1956 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Ford Steel Division Night."

"The Big Three — Ford, General Motors and Chrysler — Their Requirements in the Steel Industry," by A. J. Hole, General Manager, Metal Stamping Div., Ford Motor Co., Dearborn, Mich., J. E. Brennan, General Manager, Automotive Body Div., Chrysler Corp., Detroit, Mich. Speaker for General Motors Corp. to be announced later.

Meridian Room, Dearborn Engineering Lab, Dearborn, Mich.

LOS ANGELES SECTION

Monday, January 9, 1956 — Dinner 7:00 P.M., Meeting 8:00 P.M.

"Automatic Weighing in the Steel Industry," by R. A. Boll, General Manager, Streeter-Amet Co., Chicago, Ill.

Rio Hondo Country Club, 10627 South Old River School Road, Downey, Calif.

PHILADELPHIA SECTION

Saturday, January 7, 1956 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Are You Getting Good Returns From Your Ventilating Investment?," by Dr. Allen D. Brandt, Chief Industrial Hygiene Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Productive and Preventive Maintenance of Finishing Mills," by W. C. Whitmore, Electrical Foreman, Finishing Mills, Alan Wood Steel Co., Conshohocken, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, January 9, 1956 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Maintenance Symposium —

"A New Look at Maintenance," by Joseph Serenka, Master Mechanic, Strip Mills, Pittsburgh Works, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"The Development of a New Insulation System for Auxiliary Mill Motors," by M. W. Kitzmiller, Manager, Direct Current Motor and Generator Product Engineering, Direct Current Motor and Generator Dept., General Electric Co., Erie, Pa.

"Learning to Live With Your River," by Harold F. Miller, Fuel Engineer, Bethlehem Plant, Bethlehem Steel Co., Bethlehem, Pa.

Alumni Room, University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Data not available.

SAN FRANCISCO SECTION

Tuesday, January 10, 1956 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Bethlehem Pacific Coast Steel Night."

"Maintenance and Development Program of the Small Tonnage Steel Plant," by R. D. Bradley, Chief Engineer, and D. W. Petty, Jr., Superintendent Electrical and Mechanical Maintenance, Bethlehem Pacific Coast Steel Corp., South San Francisco, Calif.

YOUNGSTOWN SECTION

Monday, January 23, 1956 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Overhead Crane Goes Automatic," by Robert F. Rice, Manager, Crane Dept., Whiting Corp., Harvey, Ill.

"Remote Control of Equipment Over Existing Power Lines," by J. W. Bauer, Femco, Inc., Pittsburgh, Pa.

Mahoning Country Club, Girard, Ohio

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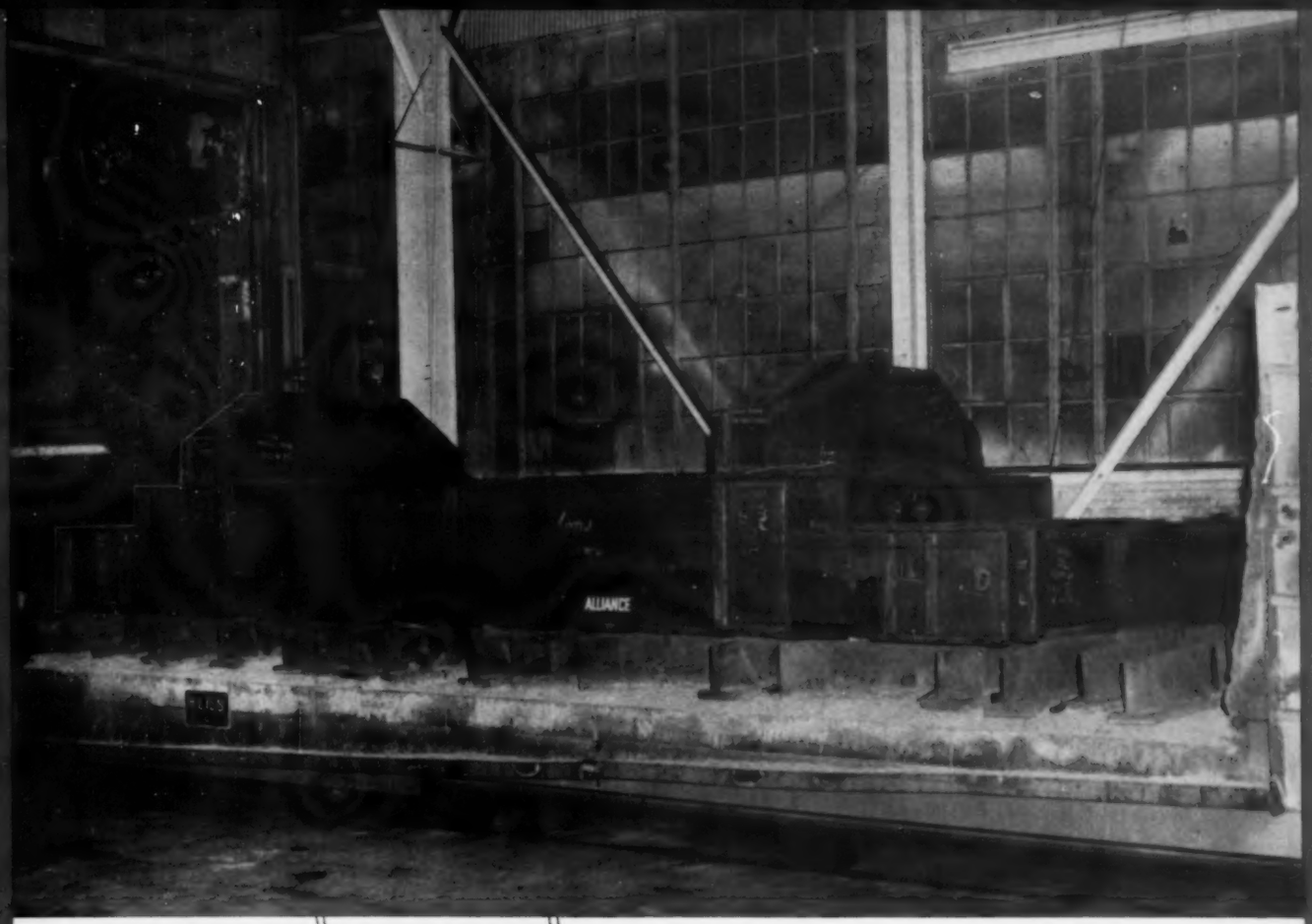

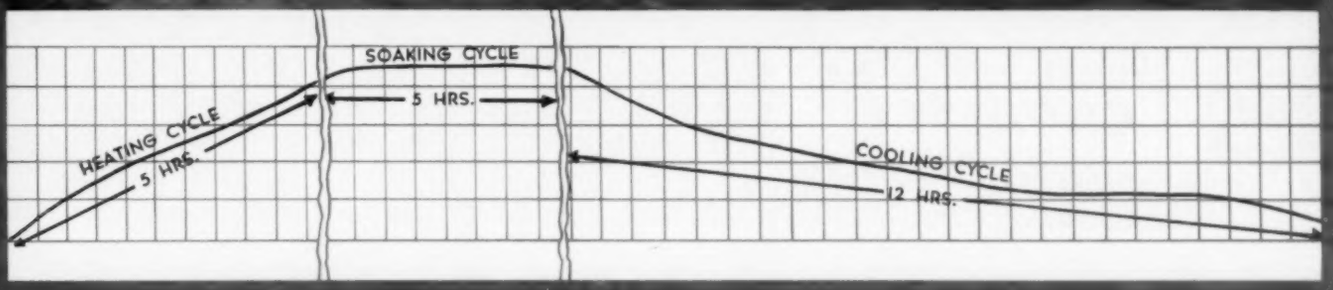

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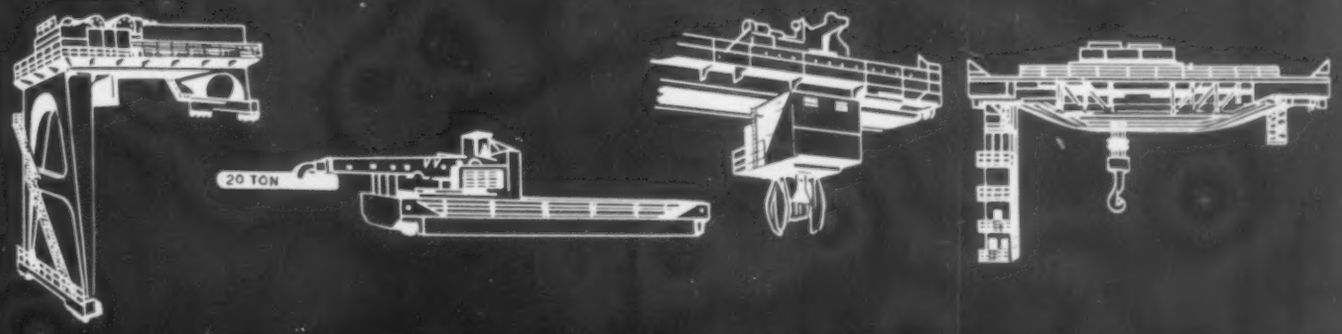
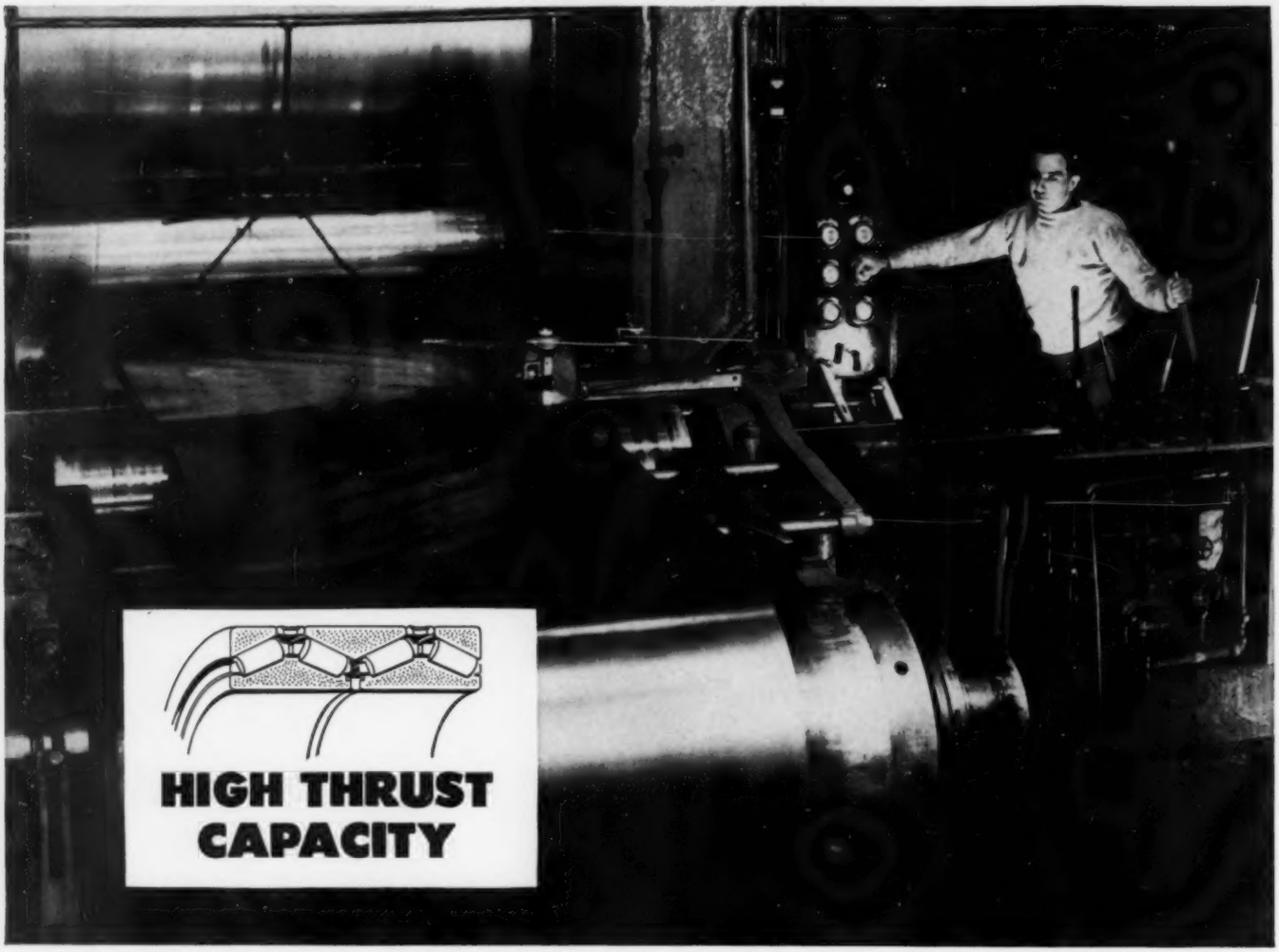


IN THE STEEL INDUSTRY, TORRINGTON *Bearings are used extensively on work rolls, back-up rolls and for many auxiliary applications such as drives, pinion stands, coilers, etc.*



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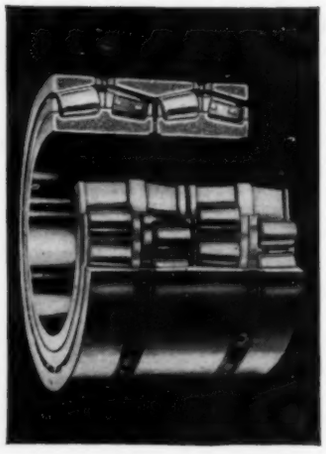

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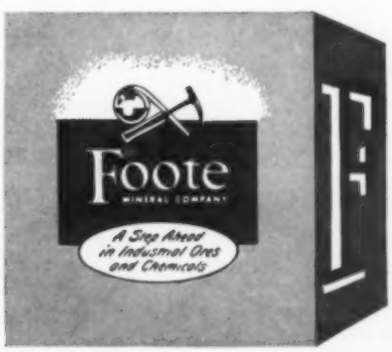

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Date-line Diary...

October 31

▲ The AISI reports that the operating rate of the steel industry for the week of October 31 is scheduled at 98.1 per cent of capacity. This is equivalent to 2,368,000 tons compared with 2,413,000 tons one week ago and 1,822,000 tons one year ago. Index of production for the week is 147.4.

November 1

▲ Titanium Metals Corp. of America announced a reduction in price of titanium sponge of 20 cents per lb to $3.75 per lb. This follows a previous reduction of 50 cents per lb in April.

November 2

▲ Ford Motor Co. reported earnings for the first nine months of 1955 were greater than in any preceding full year.

▲ Chilean miners returned to work after a 24-hr strike against American-owned copper companies. They walked out in protest against a proposed new Government code regulating labor relations at the mines.

▲ Jones and Laughlin awarded a contract to Westinghouse for the electrical equipment for the new blooming mill, universal roughing mill, and two electric steelmaking furnaces, and a contract to General Electric to build the electrical equipment for the cold reduction mill and other important items for the expansion at Cleveland.

▲ Universal Atlas Cement Co. announced an increase of 25 cents per barrel on standard cement, effective the first quarter of 1956.

November 3

▲ New York Central Railroad plans to purchase 14,750 freight cars for around $118,000,000.

▲ Inland Steel Co. will set up a new system based on purchases in the first quarter of 1954 for allocating deliveries to its customers during the first quarter of 1956.

▲ Farm exports increased 20 per cent during the third quarter of 1955 to $720,000,000.

▲ Construction outlays declined in October with expenditures amounting to $3,900,000,000 or $100,000,000 below September's total.

▲ An accident at U. S. Steel's Fairfield plant in Birmingham, Ala. killed three workers when hot metal in the blast furnace apparently broke through the floor of the unit.

November 7

▲ Ford Foundation will sell 15 per cent of its Ford Motor Co. stock to the public early in 1956.

▲ Chrysler Corp. reported profits for the first nine months of 1955 reached $8.11 a share in comparison with the 43 cents in the like period in 1954.

▲ The Commerce Dept. reported personal income pushed up to a further high in September at the annual rate of $307,500,000,000 which is $2,200,000,000 above the rate reached in July and August and $20,000,000,000 above the year-earlier rate.

▲ The AISI reports that the operating rate of the steel industry for the week of November 7 is scheduled at 98.3 per cent of capacity. This is equivalent to 2,372,000 tons compared with 2,400,000 tons one week ago and 1,874,000 tons one year ago. Index of production for the week is 147.7.

▲ Lone Star Steel Co. announced a net income, before taxes, for the third quarter of 1955 of $2,478,992 thus bringing the nine month total to $7,079,682 or $2.68 per share on net sales for the third quarter of $19,910,331 and sales during the first nine months of $54,731,873.

November 8

▲ At separate stockholders meetings of the Texas Eastern Production Corp. and the Texas Eastern Transmission Corp., a merger of the two companies was overwhelmingly approved.

▲ Employment in October increased to 65,200,000 in October, up 400,000 from September and 3,000,000 above October of 1954.

November 9

▲ U. S. Steel Corp. broke ground for erection of a new general office building at its Homestead district works.

▲ The Commerce and Labor Depts. predict construction outlays next year may reach a new high of $44,000,000,000 which is 5 per cent above the total indicated for 1955.

November 10

▲ F. W. Dodge Corp. reports contract awards for future construction in the 37 eastern states in October totaled $1,862,692,000, down five per cent from October of 1954, and first such drop since April 1954.

▲ U. S. Steel will reactivate about 500 beehive ovens at its Leisenring No. 2 mine in southwestern Pennsylvania and will start operation about December 1.

November 11

▲ The Aluminum Assn. reported primary production of aluminum in September totaled 261,211,002 lb compared with 267,101,817 lb in August and 240,664,643 lb in September 1954.

▲ Square D Co., Detroit, and Electric Controller and Manufacturing Co. of Cleveland will merge, pending approval of stockholders.

▲ Plans for expansion were announced by Standard Oil Co. amounting to $1,200,000,000 and also by Chrysler Corp. amounting to $1,000,000,000.

▲ Electric power requirements of the U. S. will reach 1,996,000,000,000 kwhr in 1980 compared with 478,000,000,000 in 1954, predicted the Federal Power Commission.

November 13

▲ The F. W. Dodge Corp. predicts further construction gains in 1956 with an expected total of about $9,450,000,000 in nonresidential building and a drop of 6 per cent in residential building to $9,890,000,000.

▲ The Bureau of Mines, U. S. Dept. of the Interior, reports consumption of scrap and pig iron during September totaled 12,060,000 gross tons compared with 11,682,720 tons in August. Of this 6,102,000 tons was scrap.

November 14

▲ National production of goods and services spurted to a record annual rate of $391,500,000,000 in the third quarter which is $6,500,000,000 above the previous high in the second quarter, reported the Commerce Dept.

▲ The AISI reports that the operating rate of the steel industry for the week of November 14 is scheduled at 98.8 per cent of capacity. This is equivalent to 2,384,000 tons compared with 2,404,000 tons one week ago and 1,892,000 tons one year ago. Index of production for the week is 148.4.

November 16

▲ Deliveries of new domestic freight cars in October were 3772 compared with 3118 in September and 1817 in October 1954, according to the ARCI. Orders in October totaled 12,843 compared with 3228 in September. Backlog of cars on order as of November 1 stood at 61,954.

▲ Steel price increases were favored by Mr. E. T. Weir, chairman of Weirton Steel Corp., to substantiate finances required for new expansion of its productive facilities amounting to $200,000,000.

November 17

▲ The Aluminum Assn. reported primary aluminum production in October totaled 269,312,211 lb compared with 261,211,002 lb in September and 250,178,989 lb in October 1954.

November 18

▲ According to the Labor Dept., housing starts in October declined to 107,000 units compared with 113,000 new homes begun in September and 110,700 in October of 1954.

▲ Steel scrap advanced $1 to $2 a ton to $47 a ton for No. 1 heavy melting industrial to steel mills in the Chicago area.

▲ The proposed merger of Bethlehem Steel with Youngstown Sheet and Tube will be submitted to a court test by the Justice Dept. any time the companies indicate a definite intent to go further with the plan, said Attorney General Brownell.

▲ Wheeling Steel's steelmaking capacity will go up nearly 13 per cent in a $65,000,000 expansion program recently announced. The facilities to be installed at Steubenville include two oxygen-blown converters.

November 21

▲ According to a survey by the AAR, railroads will order 87,000 freight cars in the last two months of 1955 bringing the year-end backlog to 145,000 cars totaling $1,200,000,000.

▲ Jones and Laughlin announced increases in price of extras on some structural shapes which will vary from 30¢ to $1 per 100 lb.

▲ The AISI reports that the operating rate of the steel industry for the week of November 21 is scheduled at 99.0 per cent of capacity. This is equivalent to 2,389,000 tons compared with 2,394,000 tons one week ago and 1,915,000 tons one year ago. Index of production for the week is 148.7.

November 22

▲ Directors of General Steel Castings Corp. approved arrangements for the acquisition of National Roll and Foundry Co. of Avonmore, Pa. for an exchange of around 15,600 shares of General Steel common stock.

▲ Machine tool orders in October increased to $103,400,000, a sharp rise over the September total of $61,300,000.

▲ The U. S. Dept. of Commerce stated that shipments of gray iron castings during September amounted to 1,253,000 short tons or 2 per cent above August's shipments of 1,226,000 tons and 36 per cent above the level for September one year ago. Shipments of iron and steel castings during 1954 totaled 13,538,000 short tons which is 18 per cent below the 1953 shipments. The 1954 total consisted of 11,532,000 tons gray iron castings, 822,000 tons of malleable iron castings and 1,184,000 tons of steel castings.

November 28

▲ A recent announcement by Earle V. Grover, president of the AISC, stated that about 2,700,000 tons of fabricated steelwork will be shipped by the fabricating industry in 1955.

▲ New car orders in the first 10 days of November dipped to its lowest number since early January. The average number declined to 18,777 daily which was 7 per cent lower than the October rate, but 59 per cent above the rate one year ago.

▲ The Federal Power Commission authorized Pacific Northwest Pipeline Corp. to import natural gas from Canada into Idaho, Oregon and Washington at a rate of 300,000,000 cu ft daily. The line is expected to begin shipments around November 1957.

▲ Iron ore, coal and grain shipments down the Great Lakes during October were the highest for the month since 1944, according to the Lake Carriers Assn., with a total of 20,517,596 net tons which is slightly over 5,000,000 tons above the October 1954 total.

▲ The AISI reports that the operating rate of the steel industry for the week of November 28 is scheduled at 99.2 per cent of capacity. This is equivalent to 2,394,000 tons compared with 2,416,000 tons or 100.1 per cent capacity one week ago and 1,941,000 tons one year ago. Index of production for the week is 149.0.

November 29

▲ Pittsburgh Steamship closed the iron ore hauling season with a total haul of ore of about 23,600,000 gross tons making this one of the best years. The last boat was the Olcott which left Two Harbors November 28.

▲ Steep Rock Iron Mines announced that iron ore shipments reached a new high of 2,200,000 tons in 1955 which is 1,000,000 above the 1954 figure.

November 30

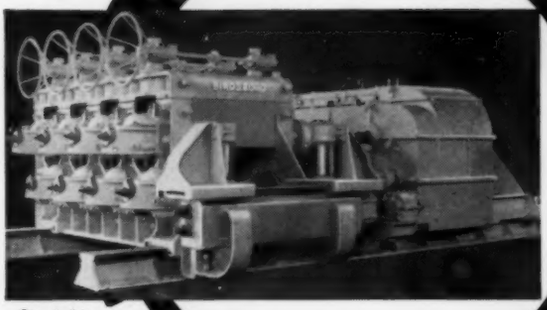
▲ Copper price advanced one cent a lb in New York. Several copper smelters are now asking 46½¢ to 47¢ per lb for refined copper compared with the one-cent cheaper rate one month ago.

▲ Great Lakes shipping was closing its season with a total ore haul of around 88,000,000 tons compared with 61,000,000 tons last year.

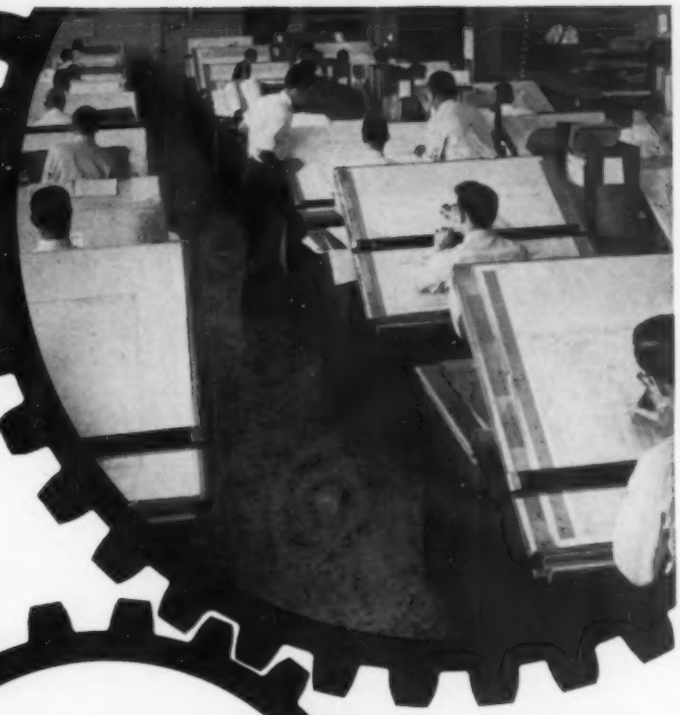
▲ U. S. Steel Corp. hiked its quotations by $2 per ton of cold rolled strip which is about 2 per cent of total steel shipments.

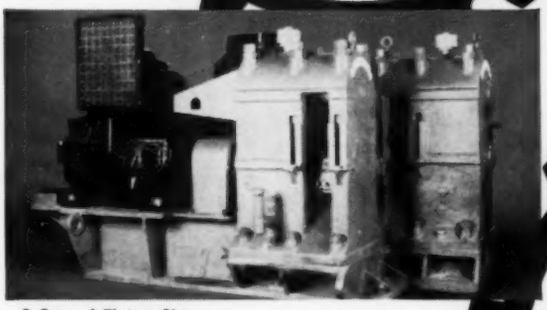
▲ The Edison Electric Institute predicted electric utilities will spend an average of $3,000,000,000 annually on construction during the next ten years.

▲ Republic Steel Corp. will erect a plant near Harrisburg, Pa. to produce riveted, corrugated metal drainage products.



Straightener





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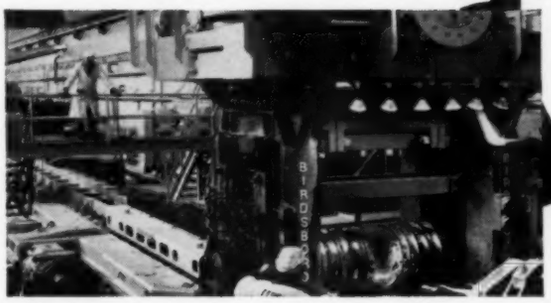
18" Roughing Mill



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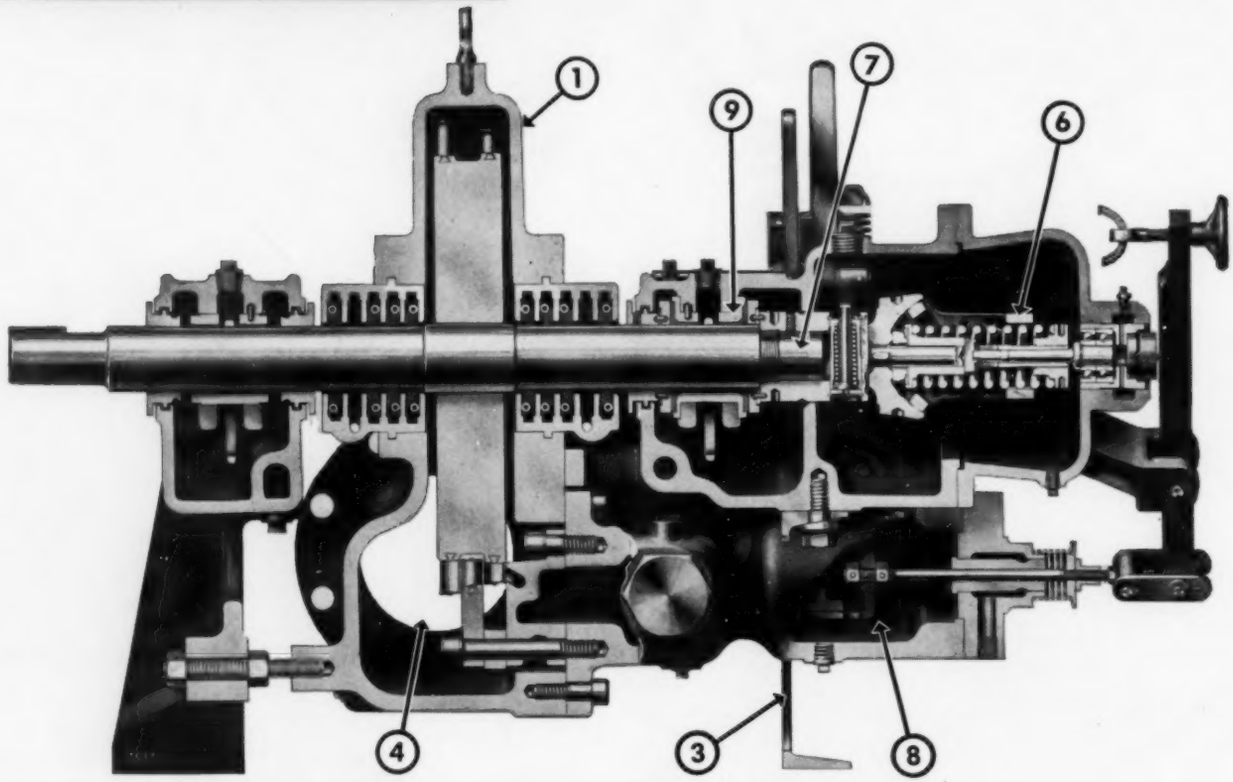

1 Case and Cover Split Horizontally on centerline for ease of maintenance.

2 True Centerline Casing Support assures distortion-free radial expansion. *Not shown.*

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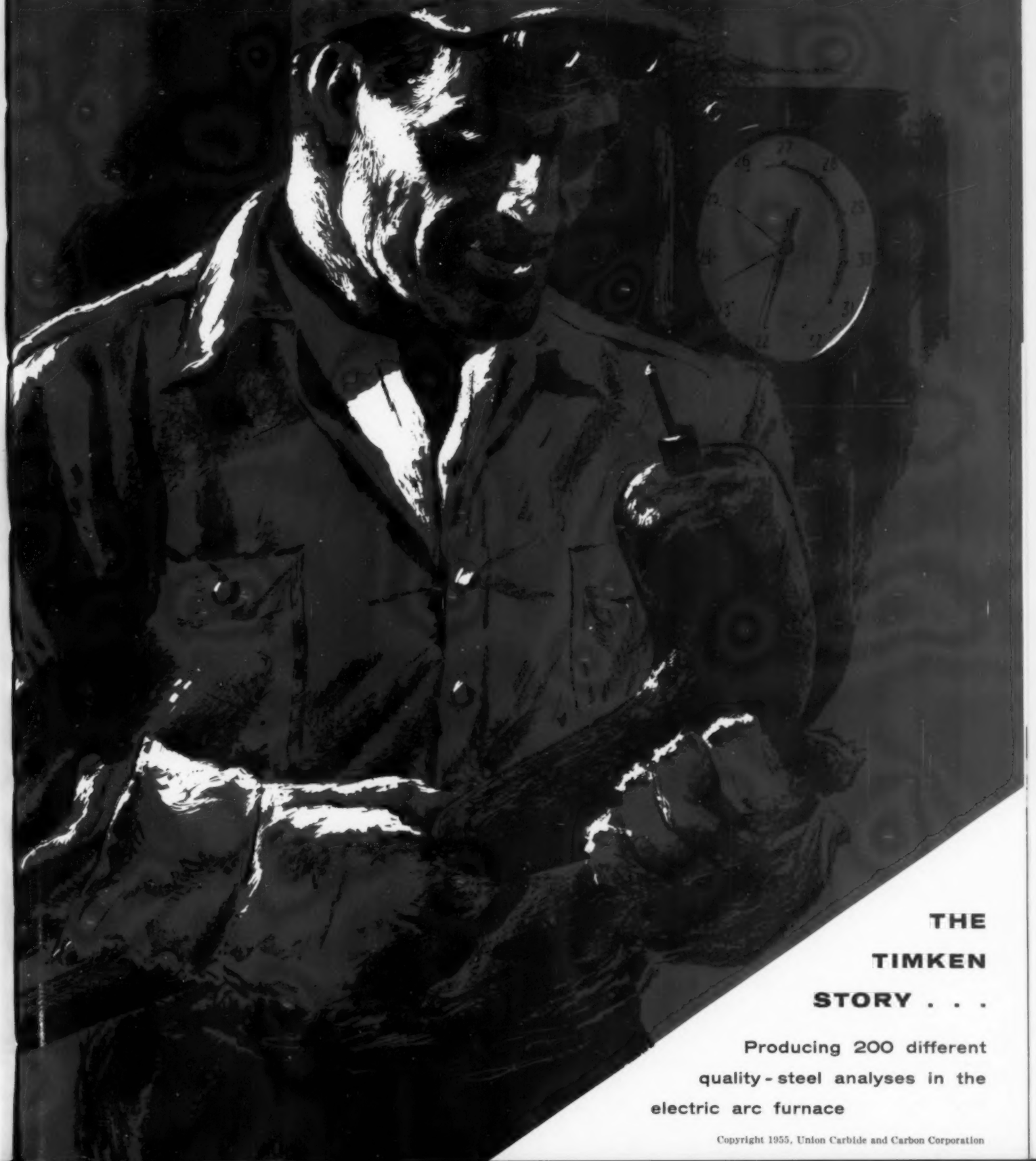
DECEMBER, 1955
Vol. 2 No. 4

NATIONAL CARBON COMPANY'S

CARBON AND GRAPHITE NEWS



THE TIMKEN STORY . . .

Producing 200 different quality-steel analyses in the electric arc furnace

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SCRAP STORAGE YARD
SCRAP SORTING BUILDING
MELT SHOP ELECTRIC FURNACES
1 - 1½ Ton Furnace
1 - 25 Ton Furnace
2 - 40 Ton Furnace
1 - 65 Ton Furnace
4 - 80 Ton Furnace
1 - 100 Ton Furnace
35" BLOOMING MILL

PRODUCTION OF QUALITY STEELS IN THE ELECTRIC FURNACE

By Harry F. Walther, *Superintendent, Melting**

To assure a steady supply of consistently high quality steel, The Timken Roller Bearing Company, early in its corporate career, decided to make its own steel.

The first electric arc furnace installed at The Timken Roller Bearing Company's steel plant went into operation in August, 1916. The first installations were small and rather crude, but from that time on the company's capacity has steadily grown to keep pace with the demand for high quality steels. This growth has occurred in number of furnaces, in size of individual furnaces, and in such technological aspects of furnace operation as instrumentation, electrical and mechanical auxiliaries and in metallurgical and process control.

Later, it was planned to install three open hearth furnaces. The first heat was tapped in March, 1927. However, for certain economic and technical reasons, it was decided to replace these furnaces with new, modern, top-charge arc furnaces of the latest design. Subsequently, the last open hearth heat was tapped on November 29, 1952, and by January 13, 1953, the Melting Department was completely converted to an all-electric shop, with an annual capacity of 650,000 tons of high quality alloy steels.

Why did we become an electric melt shop? Consideration of some of the problems involved in large-scale manufacture of bearing steels and other quality steels may help explain the reason for this decision to the reader not already familiar with the fundamental differences between a "job" shop operation on a wide variety of analyses and that of the integrated steel mill, producing great volumes of carbon steels within a relatively narrow range of grades.

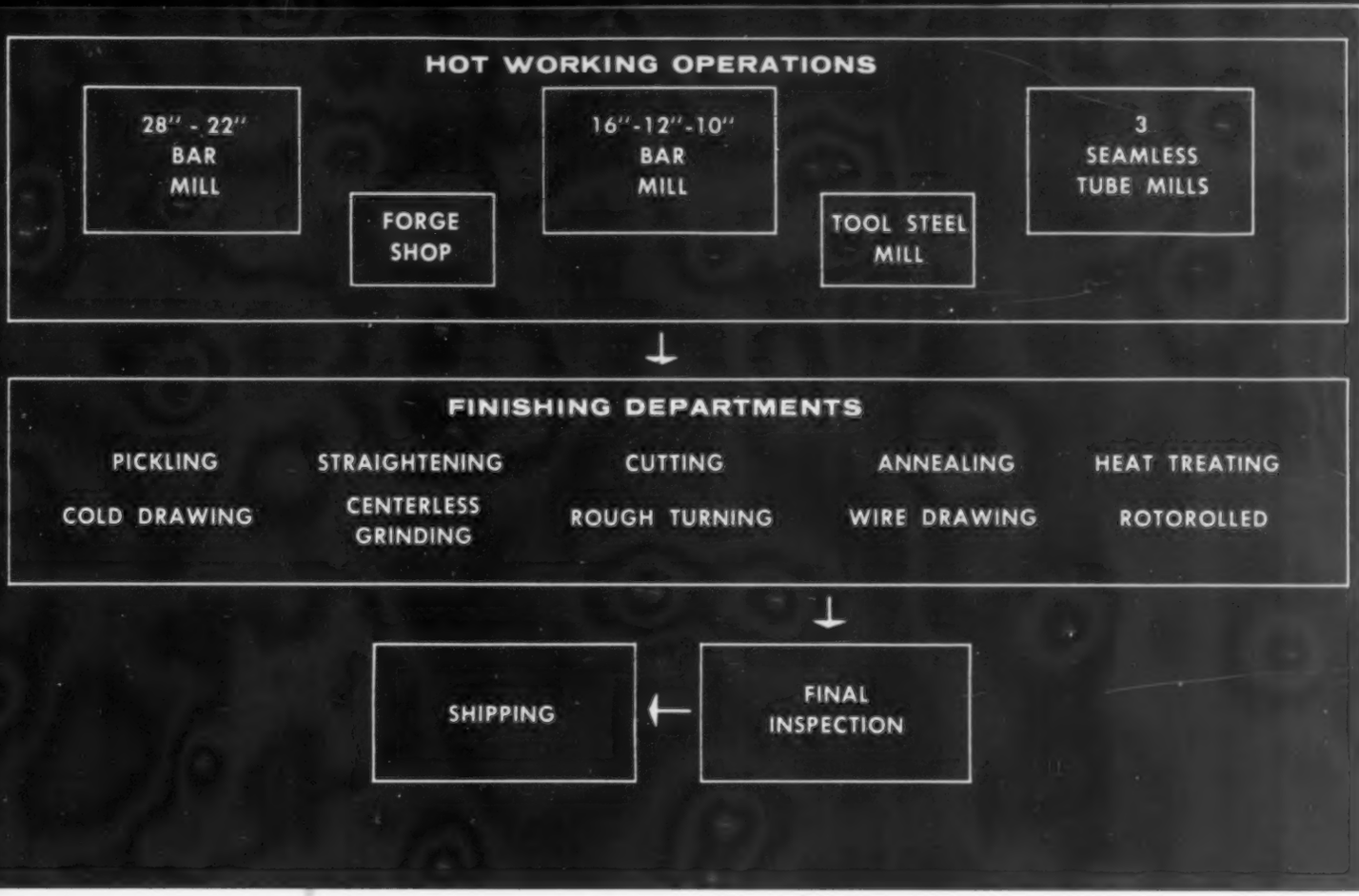
QUALITY IS ECONOMY

The Timken Company produces some 200 different steel analyses, all subject to more rigorous quality standards than those usually imposed on the more common, low-carbon steels. It is evident that, in a shop where one 25-ton heat may represent as much as $17,000, any production economy established at the risk of quality is a false one. The much closer metallurgical control afforded by the electric arc furnace, with its assurance of high, uniform quality in every heat, is possibly the greatest single source of true economy to the alloy-steel producer.

ALLOY STEELS—Special and Varied

The Timken Company's steels are varied both as to their chemistry and the uses to which they are put. Frequently, as many as eight different analyses are found in the furnaces at one time; quantities range from as little as three thousand pounds of some highly specialized or experimental analysis up to more than one-hundred-ton heats of the more widely used types. Obviously, a much greater flexibility to meet such requirements exists in the electric furnace shop, equipped with 10 units, ranging from 1½ to 100 tons, than could be obtained with any other practical combination of alloy steel-making equipment.

*The Timken Roller Bearing Company



MULTIPLICITY OF USES

Timken steel in the form of bars and tubing is used by virtually every major industry. This fact further complicates the problem of inventory. Demand fluctuates, both in quantity and in grades of steel required. Specifications of individual customers are constantly changing. Scheduling is made difficult by the varying delivery requirements of a diversified market.

Products for this broad market include *rock bit steel* (special high carbon steel held to extremely narrow limits of controlled hardenability); *aircraft* and *automotive steels* (including alloys for jet engines); *tool steels* (including graphitic grades); and, of course, *bearing steels,* which the Timken Company supplies to 24 other bearing manufacturers, in addition to its own requirement. The great diversification of this market, with its attendant problems of inventory, places a high premium on the flexibility of the electric furnace – the speed with which it can be started up or shut down, ease of rebuilding and preparation for melting, its relatively short heat cycle and high yield in tons-per-hour.

While, in general, the above considerations do not shed much light on the relative merits of electric furnace vs. other methods of steel-making, they *do* explain why The Timken Roller Bearing Company's Steel and Tube Division operates an all-electric melt shop. Now, just what is involved, production-wise, in quality steel-making by the electric arc furnace process?

SCHEDULING

Our first consideration in scheduling a heat is the customer's final application of the steel. Detailed records are kept of practices used in previous melting of all analyses, from which it is possible to determine the best practice for each current job.

The Production Department initiates the schedule, with all information relating to type, quantity, size and tolerances required by the order.

In the Metallurgical Department, complete melting procedure is outlined from melt-down to tap and on through the other mill operations. Melt shop supervisor and melter, working from these data, are able consistently to deliver a metallurgically-controlled product from raw material to ingot.

CHARGE

Availability and proper identification of raw materials is of particular importance to the large, alloy steel shop. Slag-making materials, alloying ingredients and scrap must be of the highest, *uniform* quality possible to speed selection of the charge and to assist in standardizing slag-making procedure. There are some 35 classifications in our own shop and all incoming raw materials are carefully checked against strict specifications.

If the analysis to be made involves such non-oxidizing elements as nickel and molybdenum, a high percentage of specification of these elements is charged, either as scrap or in other available forms. Oxidizable elements like manganese and chromium are generally held to a minimum except for the obvious exception of a high percentage of stainless scrap charge. In the latter instance, we employ a special practice for the removal of carbon, using oxygen, followed by "turning" of the slag for practical recovery of the oxidized elements.

Undesirable elements such as phosphorus and sulphur are kept below specification in the charge or low enough that they can be easily reduced to the required minimum during normal processing. In the large job shop, heat time and correct analysis are highly dependent on the availability and proper classification of all charging elements.

(continued next page)

OXIDIZING PERIOD

As in the production of most quality steels, the Timken Company uses a two-slag, basic practice: an oxidizing slag followed by a reducing slag. During the oxidizing period, such elements as carbon, phosphorus and some sulphur are removed from the bath by oxidation and slag-metal reactions. This is accomplished by adding lime to the slag and introducing oxygen to the bath as ore, scale, sinter or gas. The oxidizing period normally is concluded when carbon has been lowered to the specified level. At the end of this period, the slag attains a weight of 2 to 4 per cent of the metal bath, a weight-per-cent ratio of lime to silica in the range of 2.0 to 2.8, and a total FeO content of from 5 to 30 per cent, depending, generally, upon the carbon level in the bath and the basicity of the slag.

The literature is rich in data covering the effects of oxidizing slags on such residuals and additives as carbon, manganese, silicon, chromium, phosphorus and sulphur in the molten bath. More and more, metallurgy is extending its investigations beyond the physics of metals and into the realm of their complex chemistry in the search for a clearer understanding of slag-metal and metal-gas reactions.

REDUCING PERIOD

Following slag-off, and such additions as are necessary at that time, a reducing slag is added for the purpose of further refinement. Slag volume during this period is usually 2 to 4 per cent by weight of the bath. About 20 minutes are required for the slag to "shape up". After the reducing slag is added, and throughout the refining period, judicial additions of a reducing agent such as coke and silicon are made to keep the slag "deoxidized". Silicon may be substituted for coke in melts where carbon pickup is a hazard.

Refining-slag make-up varies widely, but in normal carbide slag practice it will have a lime-to-silica ratio in the range of 2.2 to 4.5 per cent by weight, a calcium carbide content of about 0.5 to 4.5 per cent, FeO content under 2 per cent, and a CaF_2 content in the range of 2 to 15 per cent. Here, again, the literature includes a wealth of findings on many aspects of refining-slag reactions.

The refining period ends with addition of such alloying elements as are shown by test to be needed to meet specifications. Following the refining period, final deoxidation is effected by additions of aluminum or other suitable materials, if required, and the heat is ready to be tapped.

POURING THE INGOT

During the pouring process, as in every previous stage of production, precaution is taken to prevent contamination of the metal. All molds are vacuum cleaned in the pit and mold plugs are made of a special, all-carbon mix instead of the more common clay, in order that non-metallic inclusions may not be introduced into the ingot. We have found that good housekeeping contributes to the good work-habits so necessary to uniformly high quality.

All ingots have ceramic hot-tops and are cast at a rate calculated to maintain desired surface and internal quality. The pouring nozzle is a ceramic refractory which is tar-impregnated to reduce bore erosion and thus makes possible a sustained, uniform rate of pour.

PROCESS CONTROL

Repeated mention has been made of the necessity for close quality control in the production of alloy steels and of the features of electric furnace operation which make this control possible. However, these features are only the instruments by which high quality *can* be achieved and maintained. In order to employ them properly, an accurate knowledge of what is in the furnace and of what is happening to the metal in the way of temperature, slag chemistry and chemical composition of the bath is required at every stage of production.

During the oxidizing period, basicity of the slag is very important. Measurement of slag basicity is obtained by the "pancake" method of visual inspection. Another vital factor in alloy steel production is bath temperature. The Timken Company was among the first to use immersion thermocouples for accurate bath-temperature determinations and it is in good part due to our success with this method that it has become virtually standard in the industry. Temperatures are directly related to power input and a detailed graphic record of the latter is kept as an important item of process control. In addition, a graphic record is kept of all immersion thermocouple readings taken during the heat.

As soon as the furnace charge has been melted down, a sample is taken and immediately analyzed for type and percentage of alloys present. With this "melt-down" test report

before him, the melter determines the alloys that must be added to adjust the steel to specifications. Following slag-off and during the refining period, additional metal samples and temperature readings are taken for final adjustment of the melt.

When the metal is teemed into ingots, final samples are taken to determine the "ladle analysis". Because it includes residual aluminum, the ladle analysis yields, among other valuable data, a quick and accurate indication of inherent grain size which is very important information for the process metallurgist. This test and those made on samples from the subsequent blooms comprise the official chemical analysis of the heat which is sent to 30 individuals or departments in the company.

The Timken Company employs both conventional wet chemical analysis and spectrographic methods – the latest being a direct-reading Spectrometer which reduces the time required for a complete analysis from about 45 minutes to six minutes. The value to the melter of such rapid determinations is incalculable. Heats need no longer be held for long periods in the furnace pending reports. The melter receives his data while the heat is still in approximately the same condition as when the test sample was taken.

Melt-down and prelim tests, except for carbon, phosphorus and sulphur, are run on the Spectrometer only. Similar tests on the ladle are double-checked by wet chemical methods. A pneumatic tube system carries the test samples from melt floor to laboratory. Results are telautographed to the melter who enjoys instantaneous, two-way communication with chemical and spectrographic labs. Other direct-line, two-way communications include those from cranes to melt floor, floor to pit, pit to cranes, and stock-house connections with both cranes and melt floor. As a part of its records system, the Timken Company keeps a heat-log for every melt, showing variations in compositions of the metal and the slag from tap to tap.

IMPROVED TECHNOLOGY

Because it is the newest of the established steel-making techniques and because it was early identified with quality steel-making, the electric arc furnace has undergone the greatest variety and degree of refinement of any steel producing method. Furnace capacities have increased; transformer improvements have exceeded the greatest expectations of early equipment manufacturers; switch gear and power controls have reached a high state of efficiency. The electrode industry has produced electrodes of sizes and quality not thought possible fifteen years ago. Power companies have provided a stable source of energy which probably is the important fundamental requirement. However, no single phase of technological improvement by itself can lay claim to the present successful operation of our modern furnaces. The proper functioning of all component parts is an absolute necessity.

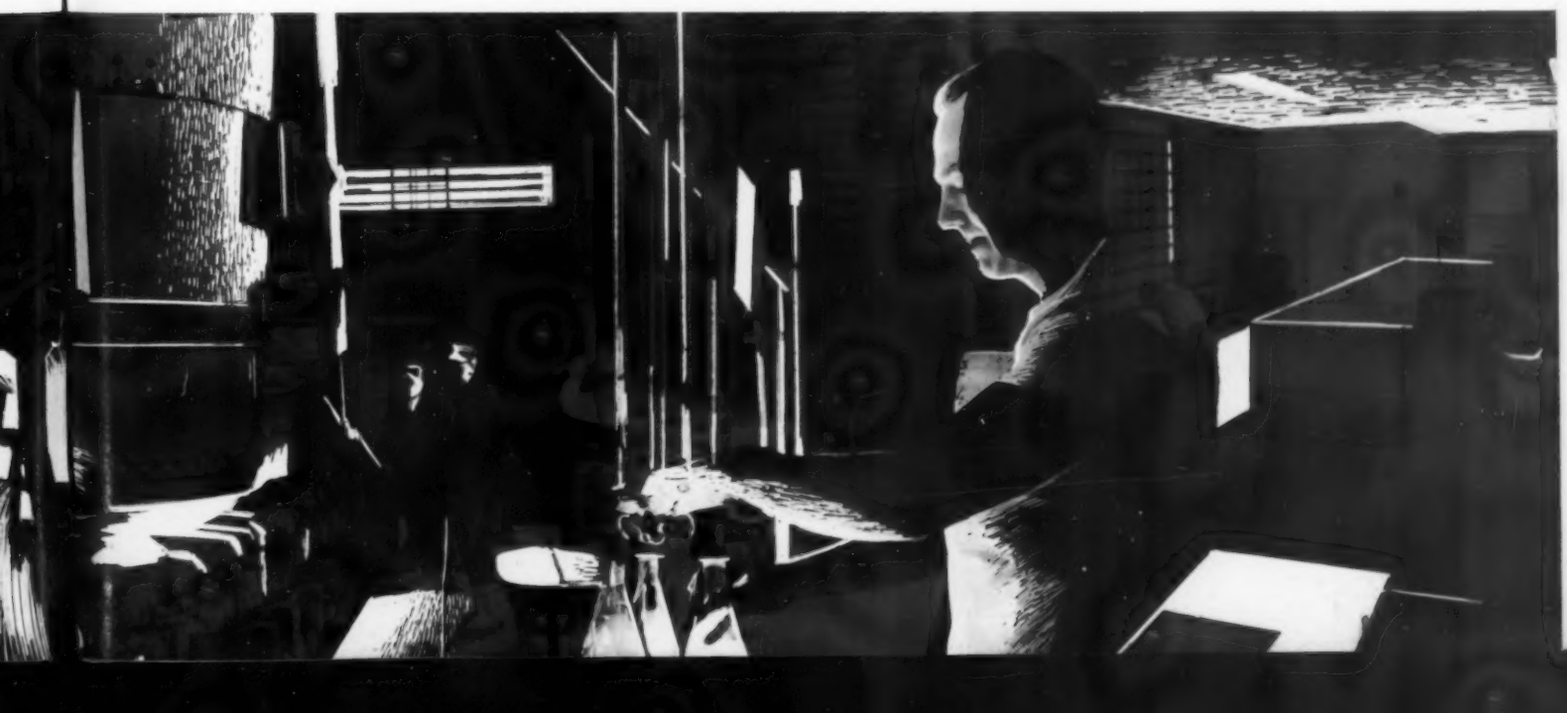
Other engineering developments have aided the melter in controlling the molten bath and in increasing production. Among these are the direct-reading Spectrometer, immersion thermocouple, carbometer, telautograph and various graphic meter recorders. Induction stirring has also provided a means for more accurate chemistry and temperature control. Much of the guesswork has been removed from melting by making use of these scientific devices. The use of oxygen in the bath has made it possible to recover vast amounts of chromium and to produce extra low carbon steels of stainless types with a minimum of difficulty.

Improved refractories have likewise played a most important part in advancing operating techniques. Fully rammed bottoms of various excellent mixes have eliminated much of the drudgery and plain guesswork from hearth maintenance. Basic brick sidewalls, particularly metal encased, have provided a distinct advantage to operators.

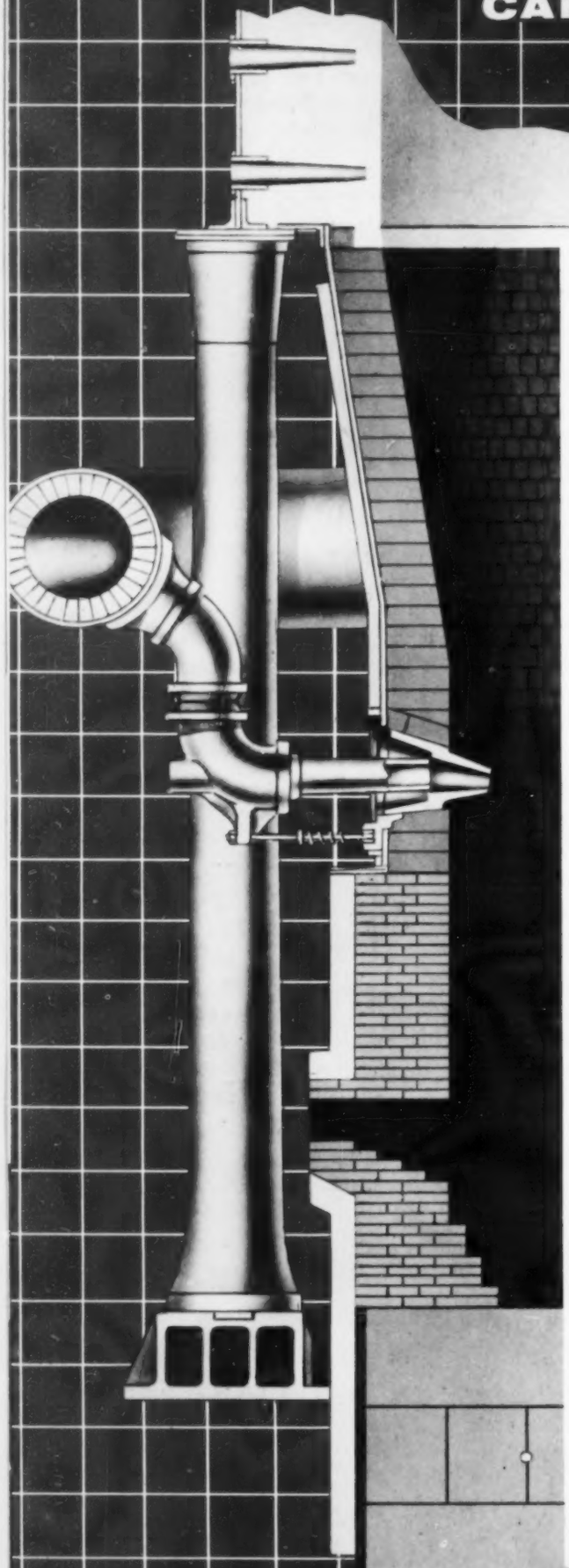
We cannot overlook the part metallurgists have played in improving metal quality. By applying the results of statistical evidence and making use of a better knowledge of slag-metal-temperature-gas relationships, it is possible to improve melting techniques to meet almost any rigid requirement desired by the customer.

Alloy manufacturers are now supplying materials which make possible the production of complex steels which, until comparatively recent times, were economically impossible.

We can only speculate as to what the future may bring. Certainly, as the demand grows for steels to resist higher and higher temperatures and to provide increasingly greater strength and wear and chemical-resistance, the electric furnace will be required to shoulder an increasingly greater share of the steel-making burden. The history of its development indicates that it will continue to improve in its ability to meet these requirements.



A report on NATIONAL TRADE MARK CARBON BLAST FURNACE LININGS



From the time of its introduction in this country as a blast furnace refractory, "National" carbon has continually gained in acceptance because of its superior service performance. Research into design and construction of carbon blast furnace linings and thorough analysis of their service advantages are now accomplished facts. Summarized here are some of the data currently available from both operating practice and research.

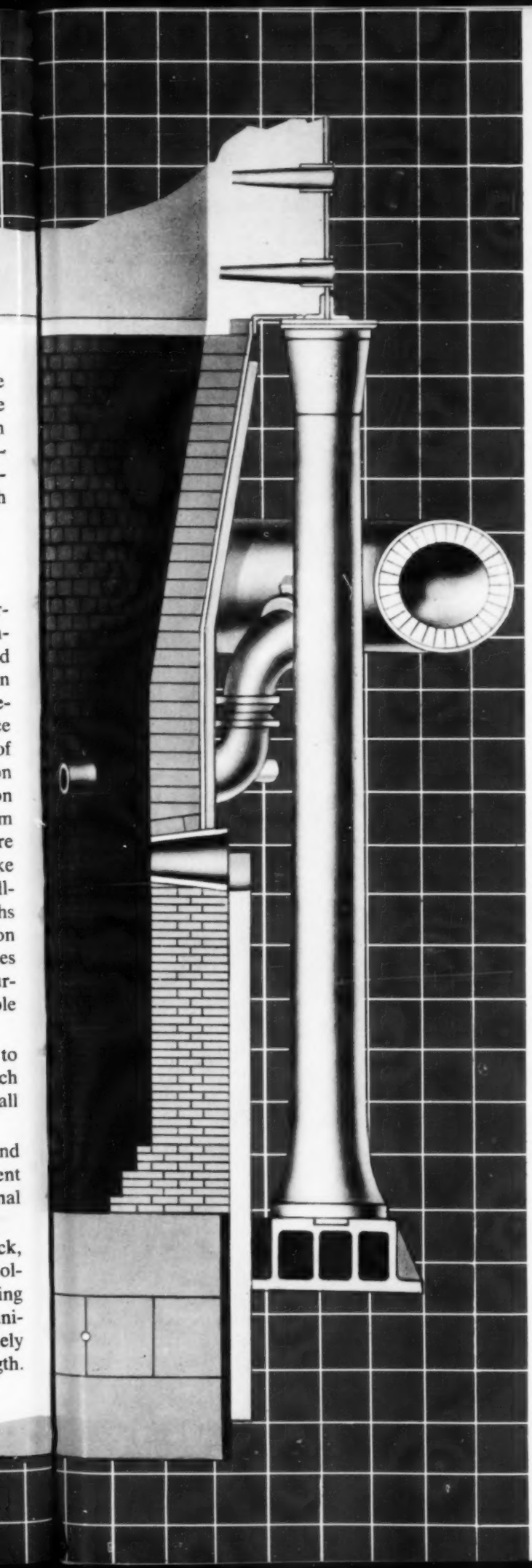
HEARTH WALL

Inconsistent hearth break-out records for materials other than carbon were a major reason for carbon's rapid acceptance. Performance of carbon in some 145 blast furnace hearths in North and South America provides strong evidence that hearth lining life can be *safely* extended by two or more times the life expectancy previously regarded as standard for other materials. Blast furnace break-outs were sharply reduced with "National" carbon linings of the original design, and features of the present "National" carbon design are an even greater improvement. Examination of carbon hearth walls between campaigns reveals very little wear and uniform thickness, in contrast to dangerous thinning of other materials. More than twenty "National" carbon linings have been removed to make a thorough analysis of their condition. The marked decrease in wall-thinning together with the absence of breakouts in these hearths have encouraged blast furnace management to identify the carbon hearth with longer, safer life. Cumulative experience now indicates that one "National" carbon hearth lining can remain in service during the life of at least two stack linings – resulting in appreciable savings of time and money.

Full-wall installations of "National" carbon brick date back to 1945, with continuous campaigns of up to 2¾ million tons. Such outstanding service has been repeated many times in part-wall patches of carbon brick work.

This accumulation of service experience and of examination and research data has firmly established the soundness of the present design, favored by the industry and recommended by National Carbon Company.

In this present design, the hearth wall is at least 22½ inches thick, constructed of carbon brick installed directly against external cooling. The quality of hearth wall linings is further assured by using "National" carbon brick of machined tolerances for desired uniformity and MC-2, a superior "National" carbon cement, extremely workable for highest quality bricklaying and high bonding strength.



The hearth shell should be air-tight and gas-tight, with the cooling restricted to the outside of the wall.

IRON NOTCH

The iron notch is a critical area of the hearth wall lining. "National" carbon in large blocks or brick shapes has proven its superiority in this location as patches in linings of other materials and in full carbon hearth linings.

Frequently, it is desirable during a stack reline to remove the carbon iron notch area for examination and replacement with carbon. This work is done at a minimum of cost and without loss of time while the stack-work above the "permanent" scaffold is in progress. The dimensional stability and infusibility of lining members made of carbon make possible a clean removal of this wall segment at the desired joints and the replacement of materials.

HEARTH BOTTOM

Linings for hearth bottoms, as for hearth sidewalls, are chosen to retain molten iron safely for long campaigns.

Salamander size has been the most common problem. Sometimes this condition is considered detrimental to furnace operation, but a more serious problem is removal of the salamander at the end of the campaign. Tapping the molten metal to the outside is less expensive than removal of solid metal, but tapping is not always possible nor is it always accomplished without accident. In any event, salamander removal is a serious undertaking, the problems and cost of which are worthy of being minimized through the use of "National" carbon bottoms.

For many years, blast furnaces have been built with very thick bottoms to accommodate salamander formation. Thus, breakouts are less frequent through bottoms than through sidewalls. However, when the bottom does fail, the damage usually is more extensive.

The heat conductivity of "National" carbon bottom blocks is sufficiently high to provide an adequate route for the central heat to travel horizontally outward to the vertical cooling when the carbon bottom is of proper thickness. A carbon bottom thickness of approximately one-quarter of the outer diameter of the lining will retain the "freeze-line" well within the carbon.

It is interesting to note that more attention is being given to the design of blast furnaces to provide cooling under the carbon hearth. Available heat distribution data indicate that bottom cooling is practical. Five such bottom-cooled carbon hearths are operating in Sweden, Austria and France.

Such bottoms can be supported on structural steel. Raising the hearth off the ground, as has been suggested, would provide a more suitable means of obtaining a gas-tight, air-tight outer shell, eliminating ground moisture problems.

The recommended "National" carbon blast furnace hearth lining now includes a carbon hearth bottom approximately 7 feet thick constructed of large blocks. All surfaces are machined for face-to-face contact. Half-round keyways are machined in each vertical face for continuous graphite key-rods to provide a "locked-in" hearth construction.

BOSH WALL

A bosh lining should withstand the high temperature and erosive action of the blast furnace (solid-to-fluid state) and particle-laden, high-velocity gases. It should also allow uniformly free movement of furnace burden for the most efficient gas-to-solids contact, a fact not always considered.

(concluded next page)

The accepted practice for years has been to imbed water-cooled copper plates in a systematic pattern throughout the bosh. The linings thus "stabilized" nevertheless cut back rapidly, exposing the nose of each plate, which protrudes inward, without protection. This condition establishes cooling "spots" which tend to chill the slag and other burden in irregular, changing patterns during operation. Downward stock movement and upward gas flow are thus hindered and "channeling" results, starting at the bosh wall. This condition is undesirable from the standpoint of gas-to-solids contact and creates wide temperature fluctuations in the stack wall. These factors are detrimental to the lining and cause "scab" formations which reduce working volume and are otherwise undesirable.

The use of imbedded cooling plates in a carbon bosh wall is unnecessary and, from the standpoint of installation and maintenance, *highly undesirable*. Carbon bosh lining blocks of special, small shapes are laid directly against a solid, welded steel jacket since cooling of the outer shell is adequate.

Construction cost analyses made by a number of organizations confirm the fact that a carbon bosh can be installed for less total cost than the internally cooled type. The greatest savings result from the elimination of cooler plates and the necessary labor time required for the tedious fitting around these plates.

Carbon is a material to which the burden will not adhere, and it maintains a smooth surface. Furnace operation is improved by the consistently free movement of the furnace burden through the bosh area.

Inside furnace diameters often have been enlarged by lining with carbon up to the mantle. Thinner walls of carbon are possible within the same hearth and under the existing stack shell. Rated furnace capacity can be increased up to 20% in this way, at minimum cost.

CONCLUSION

Safety, smooth operation and long, trouble-free service-life are now firmly established features of "National" carbon linings for blast furnaces. Furthermore, a properly designed carbon lining offers the advantage of increased furnace capacity at minimum cost. Because of its pioneer work and continuing research and development in this field, National Carbon Company can be of invaluable assistance to blast furnace users in the development of cost analyses and in recommended designs for the proper application of this superior refractory material.

National Carbon Company recommends:

HEARTH WALL

Blast furnace hearthwalls made of "National" carbon brick of machined tolerances, using a minimum wall thickness of 22½ inches, joined with "National" MC-2 carbon cement. The hearth shell should be air tight and gas tight, with adequate cooling restricted to the outside of the wall.

IRON NOTCH

Iron notch constructed of carbon brick shapes or especially machined blocks of carbon.

HEARTH BOTTOM

Hearth bottom approximately 7 feet thick, constructed of large "National" carbon blocks, with all surfaces machined for face-to-face contact, and half-round keyways in each vertical face for continuous graphite key rods to provide a "locked-in" hearth construction.

BOSH WALL

Bosh walls built of special small shapes of "National" carbon, laid directly against a solid welded steel plate jacket. Internal cooling plates are eliminated since external wall cooling is adequate.

Previous issues of CARBON AND GRAPHITE NEWS are still available.
Write National Carbon Company, 30 East 42nd Street, New York 17, New York, giving name, title and company address.

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, New York
In Canada: Union Carbide Canada Limited, Toronto

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MULTI-DUTY AIR FILTERS SERVE GREAT LAKES STEEL FROM 1930 TO 1955

Modern version of AAF Multi-Duty Self-Cleaning Air Filters which have served Great Lakes Steel for 25 years.

IN 1930, Great Lakes Steel Division of National Steel Corporation installed its first automatic, self-cleaning Multi-Duty Air Filters. During the intervening 25 years, this company has been a continuous user of these and other AAF filters—with the most recent shipment of Multi-Dutys being made to Ecorse in January of this year.

Today, as in 1930, the Multi-Duty remains a steel mill favorite for supplying clean air for motor room ventilation and blast furnace operation. This self-cleaning filter is designed for heavy dust loads. Continuous, automatic cleaning of the filter curtain assures both constant efficiency and uniform air delivery regardless of dust load. Its operating resistance remains fixed, when once established for a given dust concentration—requires no attention other than periodic inspection and removal of sludge at regular intervals.

If you want truly clean air, continuously at lowest possible cost, you've got a job for Multi-Duty—the air filter "veteran" of the American Steel Industry.

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COMPANY, INC.

American Air Filter of Canada, Ltd., Montreal, P. Q. • 302 Central Avenue, Louisville 8, Kentucky

AJAX announces

New 3-Degree 3-D DIHEDRAL COUPLINGS

THE FIRST TRULY S

New Ajax 3-D Dihedral Couplings handle up to 3 degrees of misalignment. They are priced at the same level as ordinary gear type couplings!

These new Ajax 3-D Dihedral Couplings now make it possible for design engineers to take advantage of Dihedral performance at low first cost. Precision assembly tolerances can often be relaxed, with savings at the factory and in the field.

The exclusive Ajax Dihedral principle has been proved and approved under the most severe operating conditions.

Features of the new Ajax 3-D Dihedral Coupling include:

3 degree misalignment capacity.

Load is distributed at center of teeth at the point of greatest strength.

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Exclusive Ajax Dihedral tooth design has less clearance than conventional gear type couplings.

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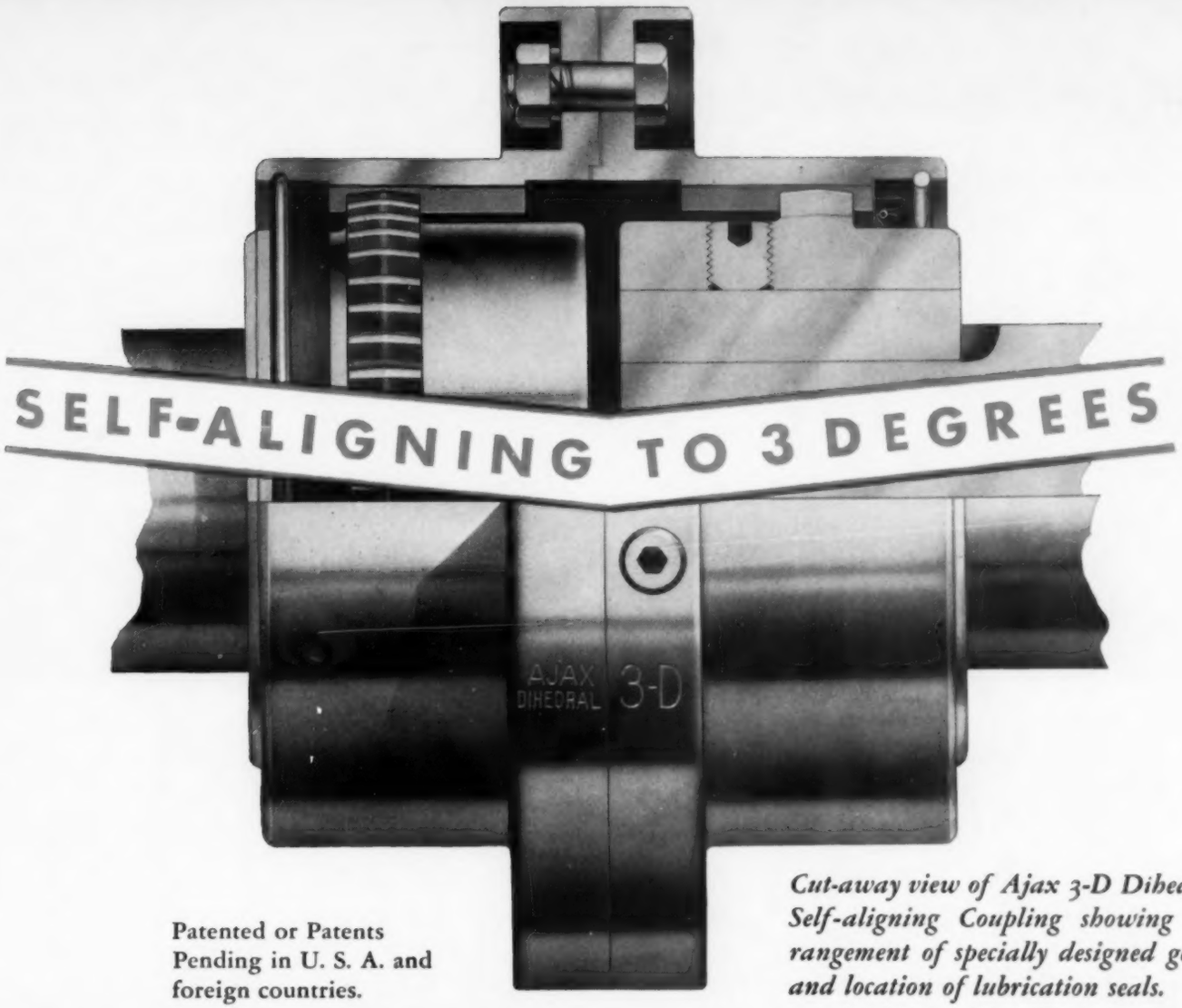
Johns-Manville "Clipper" seals keep lubricant in and foreign matter out.

Compact overall size.

Designed for NEMA motors with standard keys.

Low prices competitive with ordinary gear type couplings.

Available in 5 sizes.
Write for new Catalog No. 60.



Patented or Patents Pending in U. S. A. and foreign countries.

Cut-away view of Ajax 3-D Dihedral Self-aligning Coupling showing arrangement of specially designed gears and location of lubrication seals.

SELF-ALIGNING COUPLING

AT ORDINARY GEAR TYPE PRICES!!

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Industry News...

NATIONAL STEEL CORP. ANNOUNCES PLANS FOR EXPANSION OF STEEL MAKING CAPACITY

▲ E. T. Weir, chairman of the National Steel Corp., announced that his company will spend at least $200,000,000 over the next three years to expand steel capacity 1,000,000 tons. As a result, National Steel Corp. should have a rated capacity of 7,000,000 tons by 1959 due to this expansion without consideration of further programs.

Under this program, 100,000 tons would be completed in 1956, 500,000 tons in 1957, 200,000 tons in 1958 and 200,000 tons in 1959. Of this, additional steelmaking capacity will be split fairly evenly between Great Lakes Steel and Weirton Steel with perhaps slightly more than half going to Great Lakes Steel.

This program will require additional pig iron. It is expected that existing blast furnaces will have their capacity increased through higher sinter burdens and use of oxygen. No additional blast furnaces are included in this program. Additional steelmaking capacity is expected to be of the conventional type. At the present time, there is room for an additional fourteenth furnace at Weirton and perhaps four more units can be added to the present seventeen at Great Lakes.

One significant item in the statement was that this program would essentially complete all the expansion for which Weirton Steel has room. When additional capacity is required, a whole new plant will be required. However, the location of such a new plant is undetermined, although Weirton has plant sites available both on the Delaware River in New Jersey and in the Chicago district. Present estimates also indicate that it would not be economical to build a plant with a capacity of less than about 2,000,000 tons, and present costs of such a plant are about $325 a ton.

Mr. Weir stated that one of the greatest problems which they have would be the raising of the $650,000,000 needed for such a unit. Money in this amount can come only from higher depreciation rates or higher prices plus greater willingness on the part of people to invest in the steel industry. Forgetting inflation and future higher prices, depreciation rates should be at least $10 a ton instead of the $6 to $7 a ton which is now allowed by the Government.

Mr. Weir also pointed out that these expansion programs for steel can no longer be regarded as one shot propositions. With the present increase in population and increase in per capita demand for steel, the steel industry must put itself on a basis where it has a steady program for increasing capacity and for replacing existing uneconomical or obsolete facilities. For example, Weirton has been spending $75,000,000 a year on improvements and intends to keep on doing so. The industry as a whole he estimates must build an additional 10,000,000 to 12,000,000 tons in the next five years.

At this conference, Mr. Weir also announced that his company has increased its dividend from $3 to $4 annual rate, payable quarterly.

AWARDS COKE OVEN CONTRACT TO WILPUTTE

▲ A contract for the design and construction of three batteries of by-product coke ovens, totalling 192 ovens, and auxiliary equipment at U. S. Steel Corp.'s Clairton Works has been awarded to Wilputte Coke Oven Division, Allied Chemical & Dye Corp.

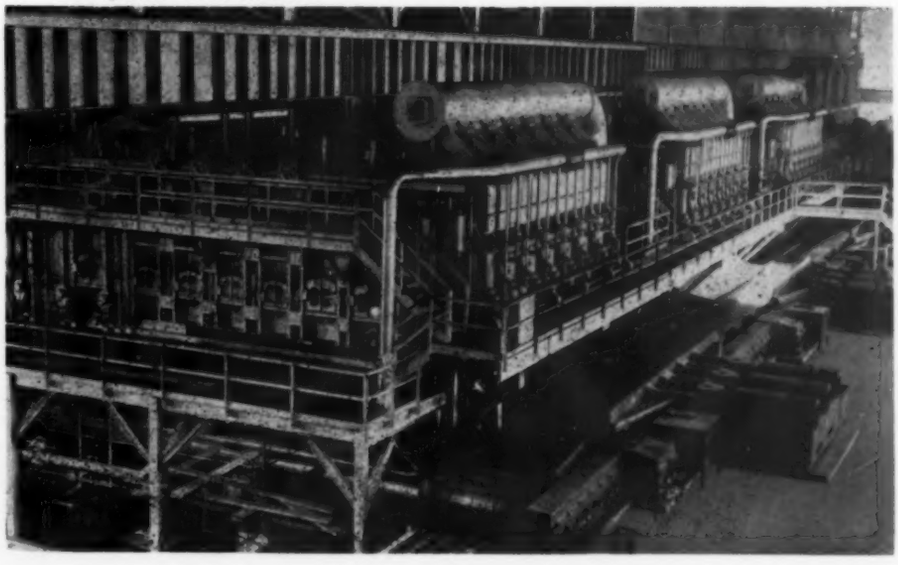
This is in addition to three batteries of by-product coke ovens, also totalling 192 ovens, with auxiliary equipment, which Wilputte is now completing at this plant.

Editor's Note: If you think you've seen the foregoing item before, you're 100 per cent correct. This story appeared in this spot last month, but one incorrect word in the heading gave the job to a competitor.

Goodness knows, there are more than enough mergers going on without our trying to promote one. The gremlins must still be with us.

GIANT REHEATING FURNACES INSTALLED AT WEIRTON

These three giant slab heating furnaces were recently placed in operation at Weirton Steel Co. The new furnaces, designed and constructed by Surface Combustion Corp., each have a normal capacity to reheat 200 tons of steel slabs to rolling temperature per hour. Each of the furnaces is approximately 118 ft long and wide enough to heat 26 ft long slabs. They were constructed as part of the extensive modernization of the continuous strip mill at Weirton.



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*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

203

THE UNITED STATES GRAPHITE COMPANY

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FORMS INTERNATIONAL PROJECTS DIVISION

▲ Republic Steel Corp. has formed an International Projects Division to handle increasing demands from foreign industries for technical, engineering and manufacturing know-how. The new division will have as its director David H. Bellamore, who will be in charge of its operations through its offices in the Chrysler Building, New York City. Mr. Bellamore has been Republic's general export manager in charge of export business since the department was formed in 1934.

The new division will make available concrete and practical help to steel producers and fabricating industries abroad. It will solve problems in both new plant construction and additions to present plant facilities by making available technical know-how, engineering direction and production practices.

GROUND BROKEN FOR EXTRUSION PLANT IN VA.

▲ Ground has been broken by Reynolds Metals Co. for a $5,500,000 aluminum extrusion plant in Chesterfield County, Va., about 10 miles from Richmond. The plant is expected to be in production by the third quarter of 1956 and will supplement Reynold's other extrusion plants in Louisville, Grand Rapids and Phoenix.

A. M. Murphy, formerly general superintendent of the company's Phoenix plant, has been appointed manager of the new plant.

NEW EXPANSION PROGRAM SET FOR GRANITE CITY

▲ Another major expansion program that will increase ingot capacity about 30 per cent by early 1958 was announced by the Granite City Steel Co. Less than two years ago the company completed an $89,000,000 expansion program that raised its ingot capacity to its present 1,080,000 tons a year.

First effects of the new expansion program will be felt late next year in an increase in the company's output of hot rolled coils and sheets. It will be near the end of the program, how-

with ASKANIA Edge Position Control

A Pittsburgh district steel mill slits this ¼" rough edge from 15-ton reels of blackplate at 3,000 feet per minute with accuracy of ± 1/64". They do this precision edge-positioning job with Askania Hydraulic Edge Position Control.

Askania Edge Position Control is a new use for the Askania Jet Pipe Regulator, long the educated muscle of the steel mill. Steel men asked for it, because they needed the dependability and simplicity of Askania in this control job.

Nothing touches the steel but a stream of low pressure air. Available force is practically unlimited. The equipment is low in cost. There is nothing delicate about it. It's built to take all the abuse that continuous operation in hard service can give it.

Find out now about Askania Edge Position Control. See your Askania Representative, or write for Bulletin 161.

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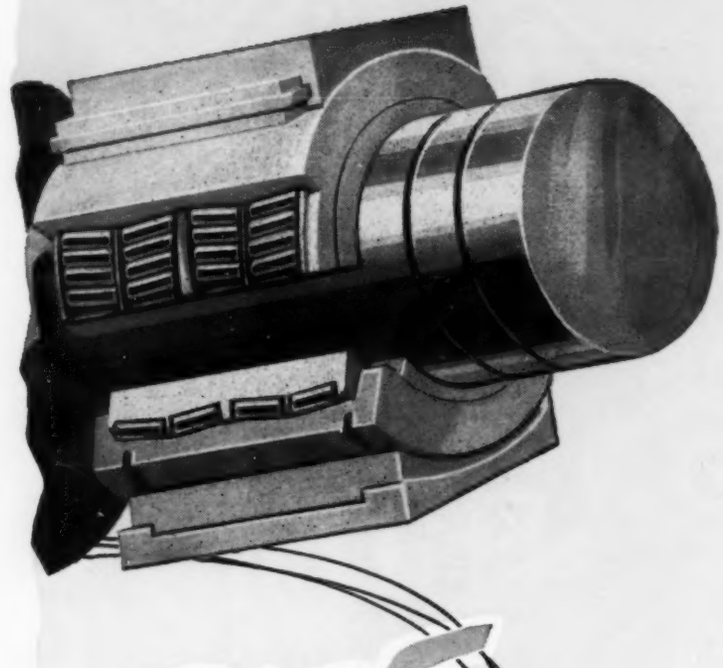

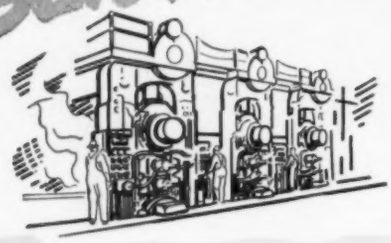

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Brooks Leadolene 375 provides safe, trouble-free lubrication of roller bearings under heaviest loads, overloads and severest shock conditions, such as experienced in heavy duty work roll service on 4 high hot strip mills, reduction mills and temper pass mills. Developed through years of research, this modern industrial lubricant provides corrosion resistance to component parts of bearing from cooling water and other contaminating actions.

Available in three grades . . .

Leadolene 375 Light: For normal or moderately high temperatures, with repellence of water a dominant factor. Excellent pumpability.

Leadolene 375 Medium: For heavier load and higher temperature requirements. Prevents leakage through seals. Excellent pumpability. Affords year around service under all temperature conditions.

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A Brooks lubrication engineer will gladly call at your request. Write, phone or wire today.

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ever, before the company can increase its production of cold rolled coils and sheets.

The new expansion will include construction of a blast furnace with a 25-ft hearth diameter, and a capacity of about 1200 tons of pig iron a day.

Included in the blast furnace project will be the building of three stoves, brick-lined regenerators enclosed in a circular steel shell, and each 104 ft high.

Another important part of the expansion program is already in part completed. This involves a substantial increase in the capacity of Granite City Steel's open hearth furnaces.

Changes have been made on the furnaces among which is the redesign of the open hearth furnace doors and structure to enable the company to use charging boxes with a capacity of 61 cu ft per box, almost double the capacity of its old charging boxes.

TO BUILD ROLLING MILL FOR KAISER ALUMINUM

▲ A second rolling mill order has been received by Loewy-Hydropress Rolling Mill Division of Baldwin-Lima-Hamilton for the new Ravenswood, W. Va., works of Kaiser Aluminum & Chemical Corp. It calls for a high-speed four-high foil mill installation with auxiliaries.

AWARD SINTERING PLANT CONTRACT TO KOPPERS

▲ A contract to build a complete sintering plant and ore bedding system at the Houston, Tex., works of Armco Steel Corp.'s Sheffield Steel Division has been awarded to Koppers Co., Inc.

Freyn Department of Koppers Engineering and Construction Division will design, build and place into operation an American Ore Reclamation Sintering Plant capable of producing approximately 1400 net tons of sinter per day. The sintering plant will be of the latest, most modern design and will include: Ore screening and storage facilities; sludge recovery equipment; trough-type and drum-type pug mill equipment; an American Ore Reclamation sintering machine 6 ft wide by 89 ft long and provided with hearth layer and sinter mix feeding equipment of modern design; forced air sinter cooler equipment arranged with handling facilities for delivering sinter to the high line transfer car.

In addition to the sinter plant, Koppers will design and install an ore bedding system that will be the fourth of its type in the United States. This bedding plant will provide a means of blending the three types of ores now used at the Sheffield blast furnace so that a uniform ore blend is delivered to the screening station.

At the screening station, the blended ore will be screened into coarse, medium and fine ores, the first two types going to the blast furnace and the fine ore going to the sintering plant storage bins. At the sintering plant, the fine ores will be mixed with controlled amounts of reclaimed flue dust, filter cake, and coke breeze which are delivered as the sinter mix to the sinter machine.

The new sintering plant and ore bedding installation is expected to be completed late in 1956.

GENERAL STEEL CASTINGS ACQUIRES NATIONAL ROLL

▲ The board of directors of General Steel Castings Corp., Granite City, Ill., at a meeting held November 21, approved an agreement with the stockholders of the National Roll & Foundry Co. to acquire, on an exchange basis, all of the issued and outstanding capital stock of National.

Charles P. Whitehead, president of General Steel, stated that its principal business has been the production of large intricate steel castings, including engineered cast steel devices for railroad use and other heavy steel castings for industrial use. National will be operated as a subsidiary of General Steel.

KAISER ENGINEERS SIGN TO HANDLE TATA PROJECT

▲ An agreement for the design, procurement and construction of a $130,000,000 steel plant expansion at Jamshedpur, India, has been signed between the Tata Iron and Steel Co., Ltd., and Kaiser Engineers Division of Henry J. Kaiser Co.

The project will increase India's current steel capacity by approxi-

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Rolling Mill Equipment

For more than 50 years Hyde Park Steel Mill equipment has been helping American industry lead the world—equipment such as—

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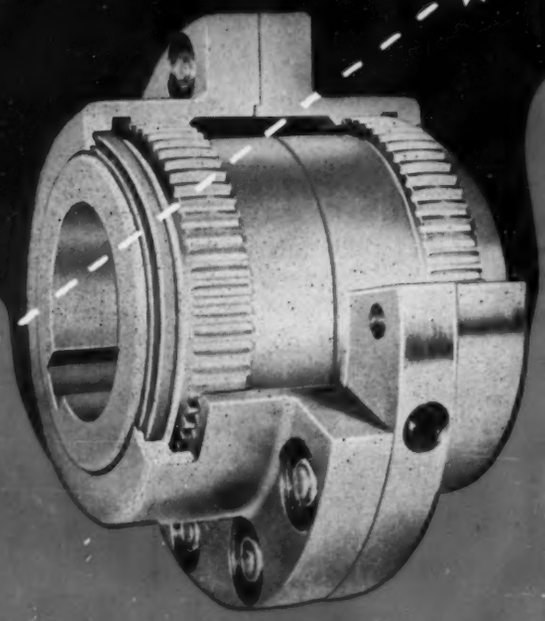
COUPLINGS



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DESIGN FEATURES

1 ALL STEEL construction from high grade steel forgings with fine tool finished surfaces.

2 ONE PIECE COVER SLEEVE is one solid forged steel unit for added safety at high speeds.

3 AUTOMATIC LUBRICATION with ever-present oil film between hub and sleeve to prevent friction or wear.

4 POSITIVE SEAL hermetically seals coupling against oil oxidation and keeps ample supply of CLEAN oil inside.

5 LONGER LINING UP SURFACE insures easy, accurate initial alignment and full capacity to handle any subsequent misalignments.

6 COVER SLEEVE BEARING prevents any added pressure to either shaft; eliminates adverse end crank action on shaft.

7 LARGER BORE permits use of smaller physical capacity for same size shaft and reduces rotating weight.

WALDRON couplings are available in sizes up to 18" shaft diameter. We specialize in furnishing couplings for unusual applications and services. We would be pleased to send you our latest bulletin 551 upon request.

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mately 45 per cent and raise the Tata plant's production from about 1.3 to 2 million ingot long tons annually. The job will require the purchase of approximately $50,000,000 worth of machinery and equipment and is scheduled to take only 30 months' time.

The expansion, providing new integrated facilities all the way from raw materials handling through finished steel, will include additional coking facilities, including a new 26-oven battery of coke ovens and a by-product plant; a sintering plant incorporating crushing and screening facilities with a capacity of 4000 tons per day; a new 28-ft diameter blast furnace; additional open hearth furnaces; a 46-in. blooming mill; a medium and light structural mill; and a continuous sheet bar mill.

NEW ELECTRIC FURNACE BEGINS OPERATIONS

▲ Atlantic Steel Co.'s new electric furnace began operations during the week of November 7. The giant Lectromelt top-charge furnace is the second such unit to be installed by the Atlanta firm within the past three years.

With a rated capacity of 75 tons, the furnace can produce more than 125,000 tons of steel annually, increasing the company's total ingot capacity by 30 per cent. The two furnaces are the largest in the Southeast and are in addition to the firm's three open-hearth furnaces.

A new dust collection system has been installed in the electric furnace building to eliminate the dust and smoke generated by the melting operations.

FOUR EXTRUSION PRESSES ORDERED FROM BIRDSBORO

▲ An order from Kaiser Aluminum & Chemical Co. for four extrusion presses has been announced by Birdsboro Steel Foundry and Machine Co.

The purchase of the presses is part of a $6,250,000 expansion program now in progress at Kaiser's extrusion plant in Halethorpe, Md. This expansion will raise capacity at the plant from 24 to 46 million lb of aluminum shapes annually. Three of the presses will be of the self-contained

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ELECTRIC MOTORS
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Wagner Type JP Explosion-Proof Motor . . . has the same quality construction as the Type EP — plus added features which make it completely safe to operate where explosive dust, gases or vapors are present.

Both Type EP and JP Wagner motors are available in ratings up to 250 horsepower. For complete information, just call the nearest of our 32 branch offices, or write for Bulletin MU-203.

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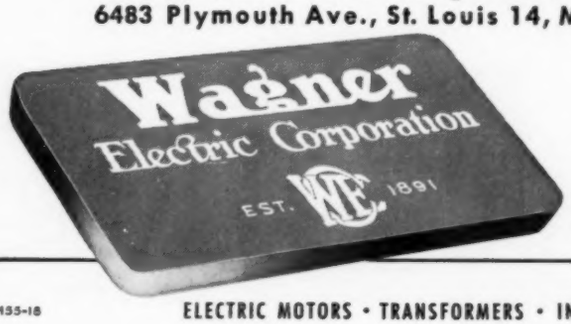
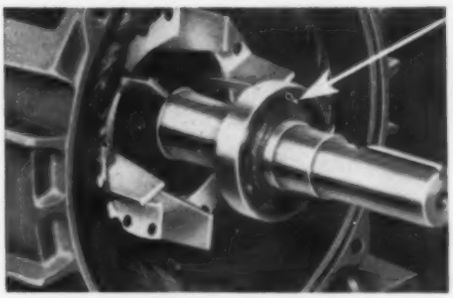
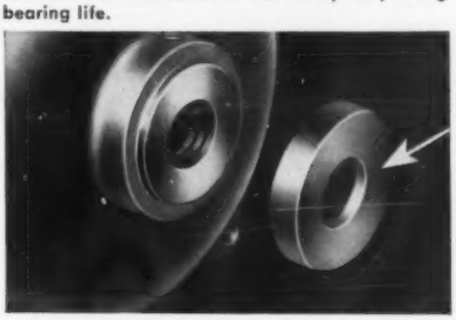


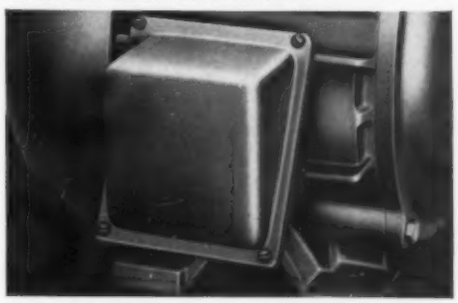


1 HEAVY-DUTY BALL BEARINGS—Highest quality bearings of more than ample capacity provide long, troublefree service.

2 BEARINGS CAN BE RE-LUBRICATED—Wagner motors can be re-lubricated when necessary to prolong bearing life.



3 BEARINGS STAY CLEAN—Both ends of these motors are equipped with running shaft seals, a machined collar mounted on the motor shaft.



4 EASY TO CONNECT—Large diagonally-split conduit box provides ample room for making connections. Leads are permanently identified.

5 NO GREASE LOSS—Bearing housings have effective seals to prevent escape of grease.

6 RIBBED FRAME—Ribs on the corrosion-resistant cast iron frames add mechanical strength and increase the surface area for more efficient cooling.

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M55-18

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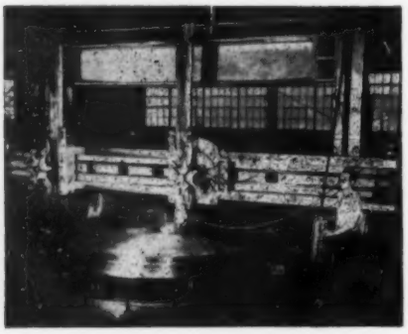

Engineered Rebuilding by Simmons *unconditionally guarantees* that your machine tools will equal or exceed manufacturers' original specifications.

And, through modernization, Simmons is adapting old machines to high-speed, high-precision production that was unheard of when the tools were new.

Today: look into the important economies in production, maintenance, and liberal tax allowances available when you turn the old machines in your plant into precision equipment for today's production!

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Unconditional guarantee... our standard since 1910

oil hydraulic type capable of exerting a load of 2,750 tons. The fourth press, the water hydraulic type with built-in mandrel manipulator for tube production, will exert a load of 3500 tons.

Birdsboro will design, build and erect the equipment with the first press scheduled to be in operation in the second quarter of 1956. The other three units are scheduled to follow closely thereafter.

SALEM-BROSIUS TO OPEN DETROIT SALES OFFICE

▲ The establishment of a sales office for the handling of its mechanical equipment and materials handling equipment lines in the Michigan area has been announced by Salem-Brosius, Inc.

The office will be located at 15846 Monte Vista Ave., Detroit, and will be under the direction of James D. Montgomery.

BRUCE ELECTRIC NAMED DISTRIBUTOR BY CLARK

▲ Bruce Electric Co., 1135 Butler Avenue, New Castle, Pa., has been appointed as a distributor for Clark Controller Co. The company will distribute Clark's complete line of pushbuttons, relays, contactors, starters, and related industrial electric control equipment.

BERRY BEARING OPENS NEW CHICAGO STORE

▲ Berry Bearing Co. has opened a new store at 6923-25 W. Archer Ave., Chicago. The new southwest location is the second such outlying store opened by Berry during 1955. Earlier this year the firm opened a store at 327 Madison St., Oak Park, to serve plants on the west side of Chicago and surrounding suburban communities.

SALES REPRESENTATIVES NAMED BY EASTON CAR

▲ Two agency representatives appointed by Easton Car & Construction Co. will handle sales for the company's industrial car division in New England and the Buffalo district of New York.

E. D. Farrell Co., Inc., of Buffalo, N. Y., will represent Easton in the New York counties of Niagara, Erie, Chautauqua, and Cattaraugus. Lee H. Long Associates, Inc., of Wellesley Hills, Mass., will represent Easton in Maine, N. H., R. I. and Eastern Mass.

AKRON SALES OFFICE ESTABLISHED BY KAISER

▲ Establishment of a branch sales office in Akron, Ohio, has been announced by Kaiser Aluminum and Chemical Sales, Inc. Address of the new branch is Room 1422, First National Tower, Akron 8.

James F. Edwards will be manager of the new branch. Before joining Kaiser Aluminum in 1954, he was associated with Jones & Laughlin Steel Corp., and also served in the aluminum industry.

KOPPERS WILL BUILD GRANITE CITY FURNACE

▲ Granite City Steel Co. has awarded Koppers Co., Inc. a contract for construction of a new blast furnace at Granite City, Ill.

The new blast furnace will have a hearth diameter of 26 ft, six in., lined down to 25 ft, zero in., at which size it will be capable of producing approximately 1200 tons of pig iron per day. This almost doubles the capacity of the present furnace and will increase the entire plant pig iron capacity almost 45 per cent.

In addition, the Freyn Engineering Department will design and construct all auxiliary equipment including such facilities as the stoves, burners, skip hoist, gas washer and valves. Construction of the furnace began early this month.

The stack of the new blast furnace will be built in an area adjacent to the old furnace. When it is completed it will be rolled into position immediately after the old stack has been torn down. This unusual method of construction has been used only three times previously in the United States. With some modifications, the existing foundation of the old furnace will be utilized in the construction of the new facilities. Construction of the furnace is expected to be finished in about seven months, with shutdown time, "iron to iron," of approximately 120 days.

AMCO

World's foremost builders of

SOAKING PITS

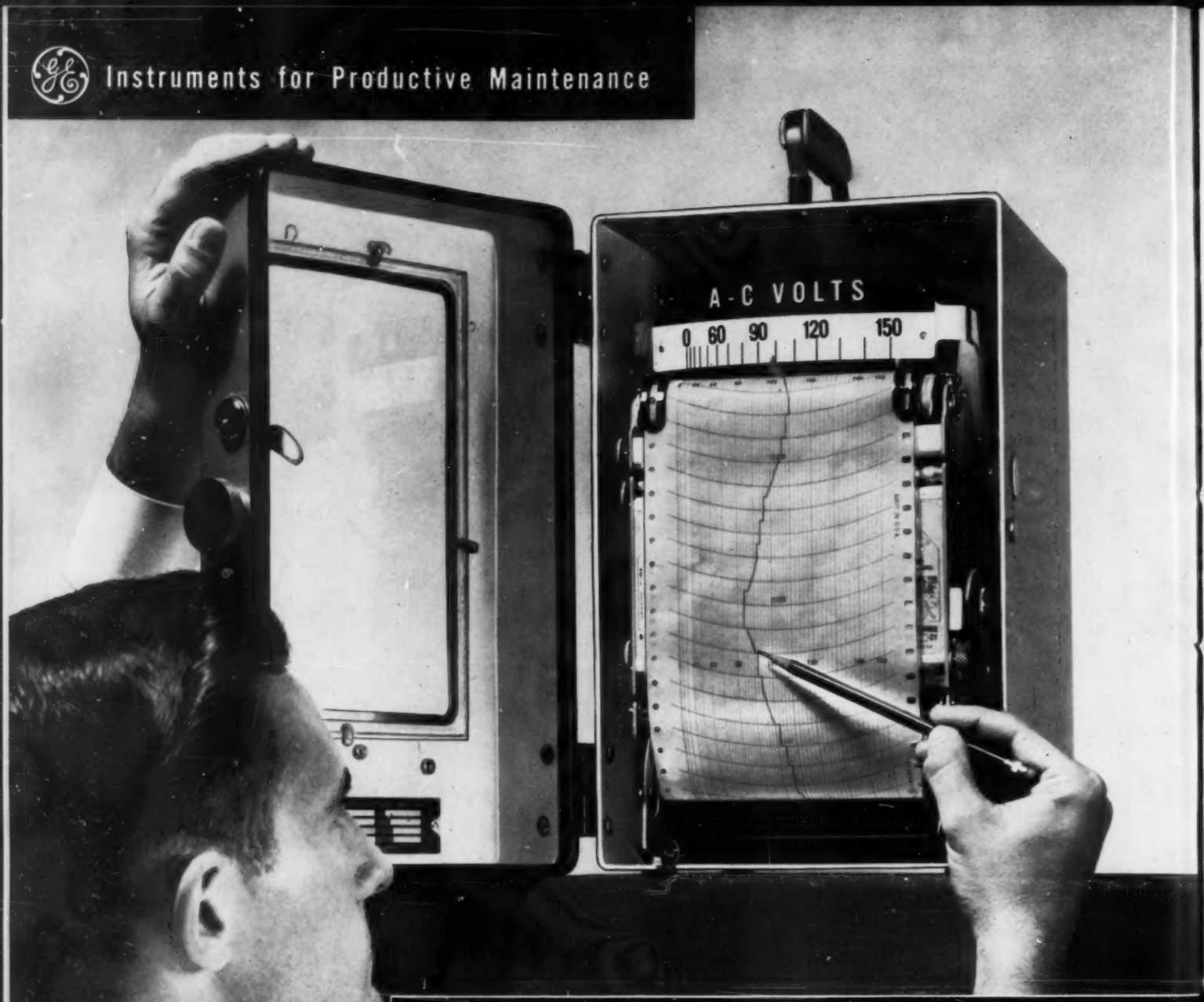
and Industrial Heating Furnaces

- DESIGN
- ERECTION
- OPERATION of complete steel plants

AMSLER MORTON
CORPORATION

CHAMBER OF COMMERCE BLDG., PITTSBURGH 19
PENNSYLVANIA, U.S.A.

Instruments for Productive Maintenance



VERSATILE NEW G-E RECORDER

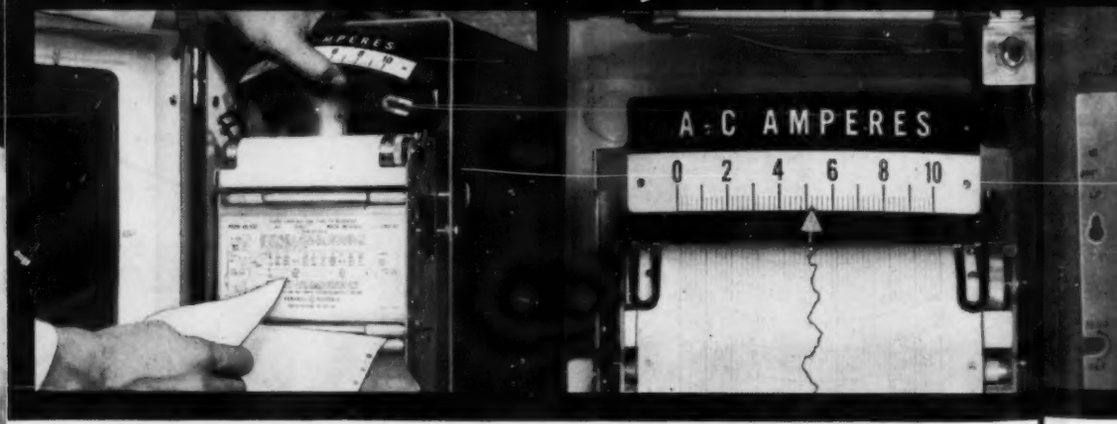


CHART SPEEDS from ¼ inch per hour to 120 inches per minute are standard on the double-speed, motor-driven chart carriage. Speeds are set by using simple instructions on the front of the carriage.

G-E RECORD ROLLS provide high color contrast between chart lines and ink. Switchboard recorders have fluorescent lamps for maximum glare-free chart illumination.

NEW General Electric Recorder Assures Sharp, Clear Records

Unique G-E Writing System Has Throw-away Inkwell; One of Six Outstanding New Cost-saving Advantages

UNIQUE WRITING SYSTEM in the new G-E general purpose recorder makes records more accurate and readable with sharp, clear pen traces. Switchboard and portable models of the new instrument can measure and record current, voltage, power, frequency or speed. Drives are synchronous motor or spring clock.

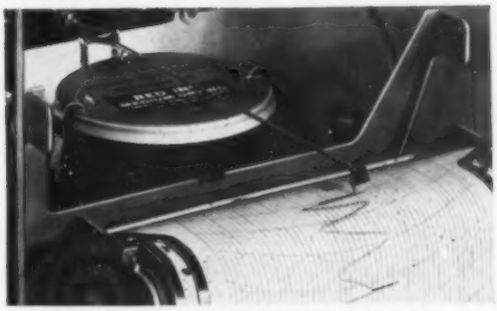
NEW THROW-AWAY INKWELL makes service quick and easy. Replacement ink comes in a sealed transparent plastic inkwell for convenient insertion. Inkwell holds a full 3 ounces, avoiding frequent replacement of ink supply.

28 CHART SPEEDS are available for more versatile recorder application. Fast, convenient changes to any one of the chart speeds may be made by simply changing color-coded gears.

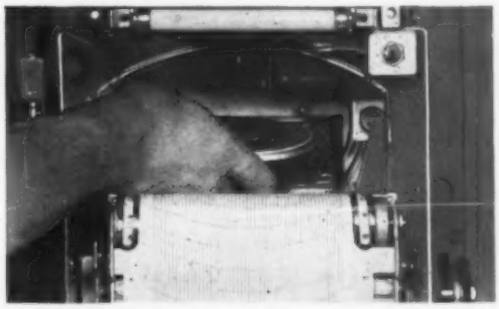
NEW G-E RECORD ROLLS are 1½ times longer than ordinary record rolls. Easier reading comes from light-green ruling in contrast with red recording ink. Faulty chart records are avoided because special paper resists shrinkage and stretching.

A 60-DAY SPRING CLOCK in G-E clock-driven models avoids the need for accessory winding devices. Hand-wound jeweled-spring clock can drive the chart for 60 days at a speed of 1 inch per hour.

NEW DESIGN makes working mechanism easily accessible. Only a screw driver and a socket wrench are needed for normal maintenance. Chart carriage takes less than 60 seconds to remove.

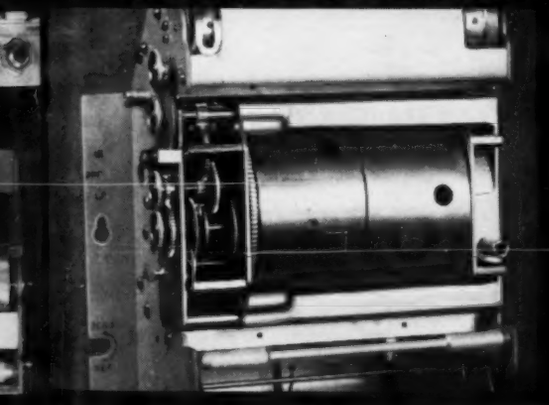


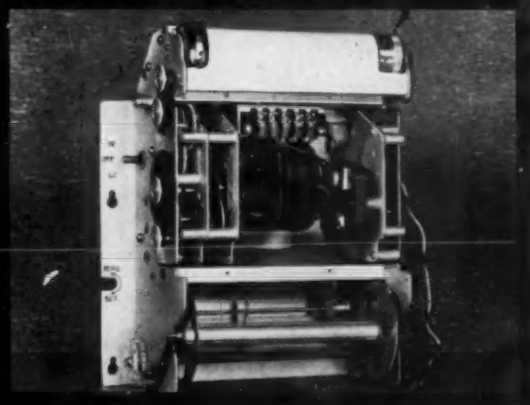
UNIQUE WRITING SYSTEM provides dependable inking with special alloy pen point, spring-loaded pen saddle, and sealed inkwell.



INK REPLACEMENT is fast and easy with sealed inkwell that slips under two spring clamps. Transparent inkwell shows level of ink.

ASSURES EASY MAINTENANCE AT LOW COST





SECTION D582-2
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, NEW YORK

Please send me the following bulletin:
GEC-1319 General Purpose Recorder, Type CH

Name.....

Company.....

Street.....

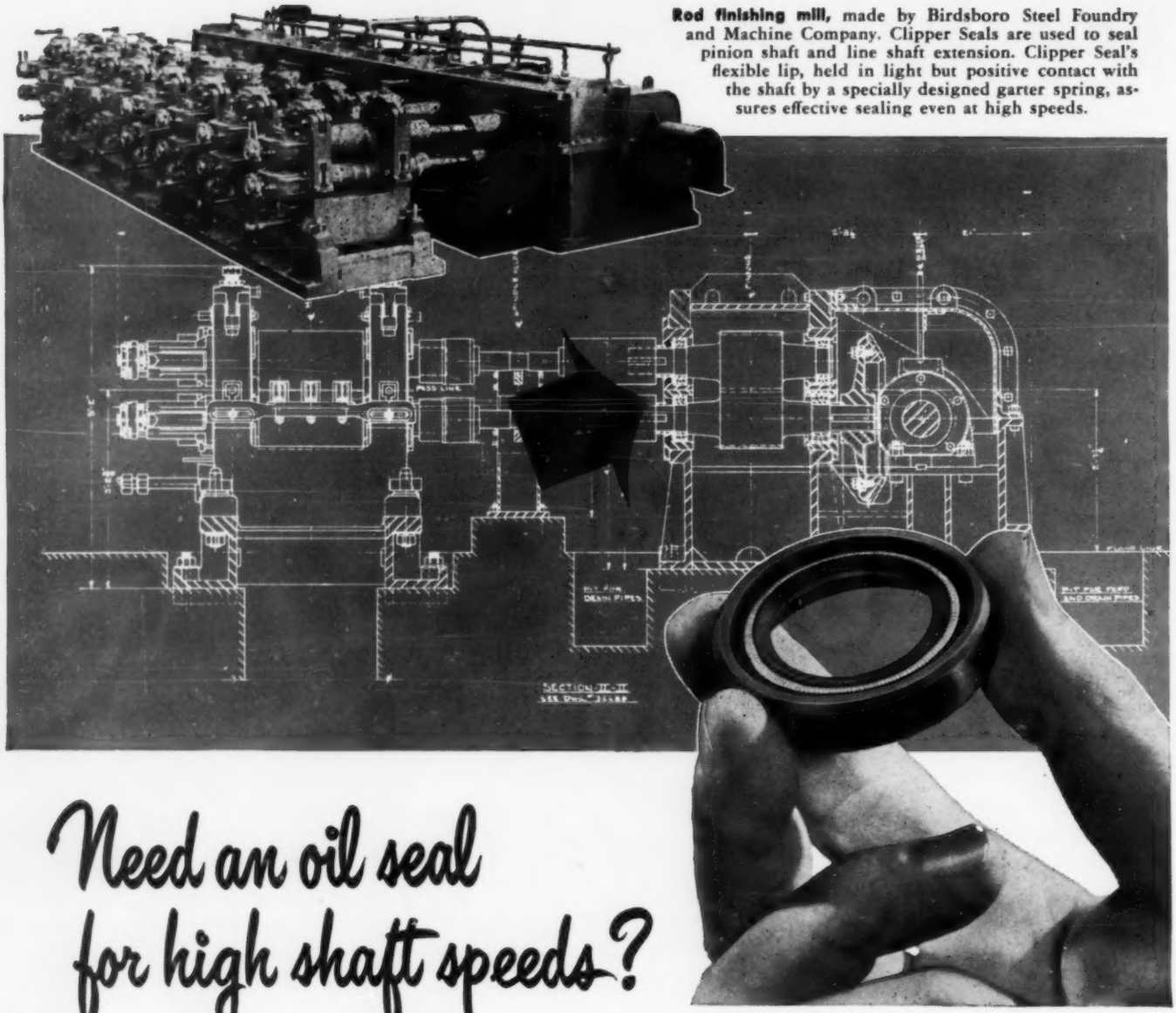
City.....Zone....State.....

HAND-WOUND SPRING CLOCK chart drives provide 60-day operation at 1 inch per hour with each winding. Chart speeds are from ¼ inch per hour to 30 inches per minute.

CHART CARRIAGE DESIGN allows all maintenance work to be done from the front of the instrument. Entire carriage may be removed in less than 60 seconds by loosening only four screws. Keyhole slots aid quick removal.

FOR FURTHER INFORMATION about the versatile new G-E general purpose recorder, contact your nearest G-E representative, or clip and mail the coupon above.

GENERAL ELECTRIC



Rod finishing mill, made by Birdsboro Steel Foundry and Machine Company. Clipper Seals are used to seal pinion shaft and line shaft extension. Clipper Seal's flexible lip, held in light but positive contact with the shaft by a specially designed garter spring, assures effective sealing even at high speeds.

Need an oil seal for high shaft speeds?

Birdsboro chose Clipper Seals

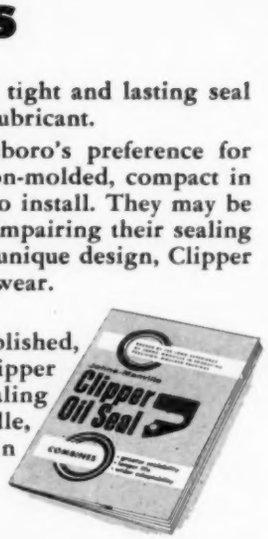
The Birdsboro 8-stand finishing train shown above is expected to operate around the clock, day in and day out. And since it is to be part of a large, high-speed, steel rod producing unit, Birdsboro designed it to be as maintenance-free as possible.

In order to minimize down time, particular attention was paid to bearing design and lubrication. The mill stands are equipped with open, water-lubricated bearings. Because of high shaft speeds, bearings in the combination spiral bevel gear reduction and pinion stand are anti-friction in type, lubricated with circulating oil, and sealed with Clipper Seals.

Birdsboro engineers chose Clipper Seals for this application because of their outstanding ability to withstand the heat of friction generated by high shaft speeds . . . and their ability to make a tight and lasting seal against the circulating bearing lubricant.

Still other reasons for Birdsboro's preference for Clipper Seals: They are precision-molded, compact in design, and exceptionally easy to install. They may be removed and replaced without impairing their sealing efficiency. And because of their unique design, Clipper Seals cause a minimum of shaft wear.

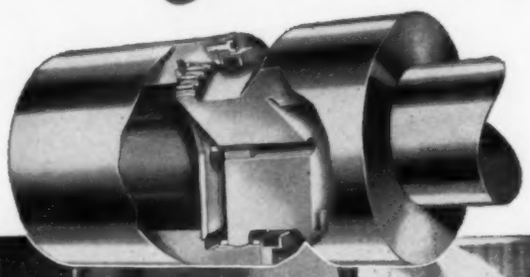
Free Brochure PK-71A, just published, shows how the wide variety of Clipper Seal designs meet almost every sealing condition. Write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.



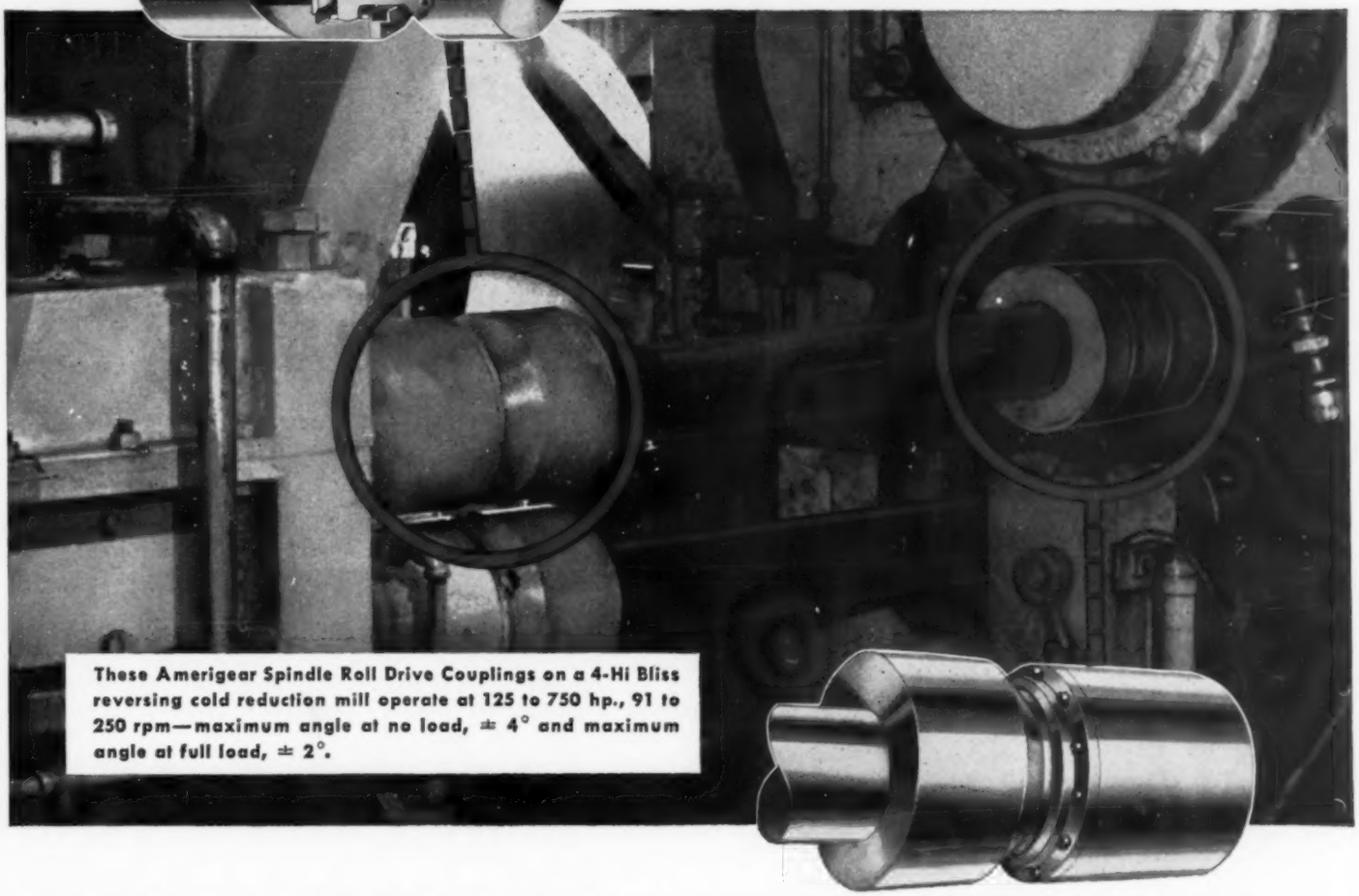
JM PRODUCTS

Johns-Manville CLIPPER SEALS

TROUBLED WITH "SLIPPER-TYPE" COUPLING FAILURES?
CONVERT TO
Amerigear® SPINDLE ROLL DRIVE COUPLINGS



. . . RUN LONGER WITHOUT MAINTENANCE
. . . MAKE ROLL CHANGES FASTER



These Amerigear Spindle Roll Drive Couplings on a 4-Hi Bliss reversing cold reduction mill operate at 125 to 750 hp., 91 to 250 rpm—maximum angle at no load, ± 4° and maximum angle at full load, ± 2°.

• HERE'S THE ANSWER TO YOUR HIGH MISALIGNMENT PROBLEMS . . .

Amerigear's Fully-Crowned Tooth Form concentrates the load towards the center of the tooth, eliminates tooth end and tip loading. This permits an extremely high degree of angular and lateral misalignment—up to ± 9° per engagement—with no wear or loss of power.

And By Accommodating For Roll Wear and varying distances between roll centers, Amerigear Spindle Roll Drive Couplings keep your maintenance expenses to a minimum. That's because they're precision-manufactured to transmit power to the rolls smoothly and continuously . . . even after repeated roll grinding . . . *without maintenance.*

Downtime Goes Down, Too because engaging roll end teeth are specially designed for quick assembly and disassembly. So the next time you're in need of flexible couplings for your ferrous or non-ferrous rolling mills, convert to Amerigear — a highly engineered solution to your every high misalignment problem.

Amerigear Engineers are ready to help you design improved operating efficiency into heavy presses, slitters, cranes, reels or other steel mill equipment. Write for Catalog 501 and Bulletin 1052, or attach coupon below to your letterhead.

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IN CANADA
CANADIAN ZURN ENGINEERING, LTD.
2052 St. Catherine St. W.
Montreal 25, Que.

AMERICAN FLEXIBLE COUPLING COMPANY
ERIE, PA., U. S. A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....
Please attach to your business letterhead.

Dept. ISE-999

For Fast, Efficient, *Low-Cost* Pickling

Install a WELDCO Mechanical Tube Pickler As Youngstown Sheet & Tube did at *Indiana Harbor*

THE WELDCO Tube Pickler combines the advantages of extra mechanical agitation and fast chemical action. Uniform descaling is accomplished by alternately raising and lowering the load on spreaders. This rolling, tumbling, spreading action speeds up descaling; then the tubes are tilted, and the liquid carries away all loose scale, completely flushing out each tube. This fast inside flushing action cuts pickling time to a minimum . . . increases efficiency. With this in mind, and to insure adequate capacity for their new pipe mill, The Youngstown Sheet & Tube Co. ordered WELDCO Mechanical Tube Picklers.

Four 10-ton Picklers were installed in their new Indiana Harbor pipe mill, making it one of the largest pipe pickling installations in the country. The WELDCO Units in this plant handle pipe from 10' to 23'6" long, provide fast, efficient flushing action, with better finish, uniform pickling and descaling, and big savings in manpower, maintenance and steam consumption.

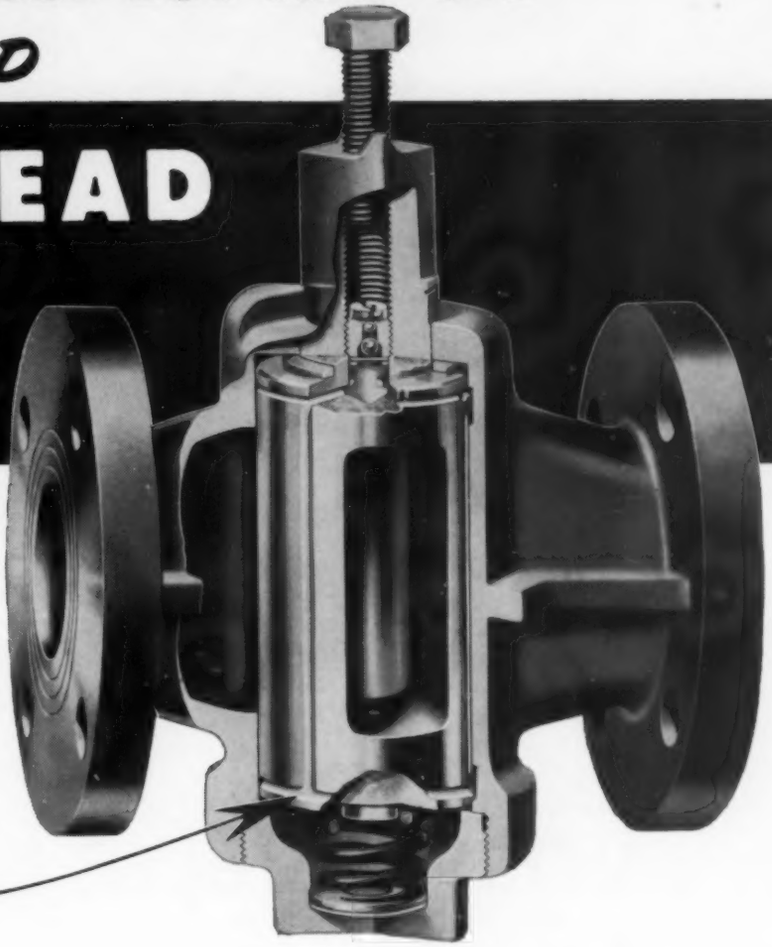
It will pay you to get all the details on WELDCO's complete line of Mechanical Picklers—available for Bars, Tubing, Coils and Sheets. Contact us for complete information, and for engineering service on your entire pickling line.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY
3719 OAKWOOD AVENUE . . YOUNGSTOWN 9, OHIO

No. 5* of 12 REASONS WHY YOU SHOULD BUY AND USE

LOW-PRICED

HOMESTEAD *Lubricated* PLUG VALVES



*SELF-FREEING PLUG PREVENTS STICKING

Homestead's exclusive completely controlled lubricant system positively prevents sticking by its instant, piston-like movement of the plug downward at the start of each lubrication. Spring and line pressure return it to stem-sealed position.

This is only **one reason why you should buy and use low-priced** HOMESTEAD LUBRICATED PLUG VALVES.

HERE ARE ALL TWELVE

1. Extra long valve life assured by very close tolerance between sealing surfaces.
2. Straight line fluid flow—streamlined ports—minimum resistance to flow—minimum pressure drop.
3. Triple head seal—two lubricant rings and reinforced Teflon stem seal prevent leakage.
4. Easy turning—plug floated on Teflon washer and reinforced Teflon ring.
5. Self-freeing plug prevents sticking.
6. Full-threaded screw prevents dirt being forced into lubricant system.
7. Quarter-turn fully opens or closes.
8. Reinforced Teflon stem seal—no cold flow—continuous, positive seal.
9. Seating surfaces protected in both open and closed positions.
10. High pressure lubricant system provides full lubricant seal around ports.
11. Leak-proof double ball and lubricant sealed check valve. No springs. No maintenance.
12. Two lubricants handle most services.

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HOMESTEAD
VALVE MANUFACTURING COMPANY
"Serving Since 1892"

P. O. Box 21 **Coraopolis, Pa.**

Without obligation, send Reference Book 39—Section 5 on HOMESTEAD LUBRICATED PLUG VALVES.

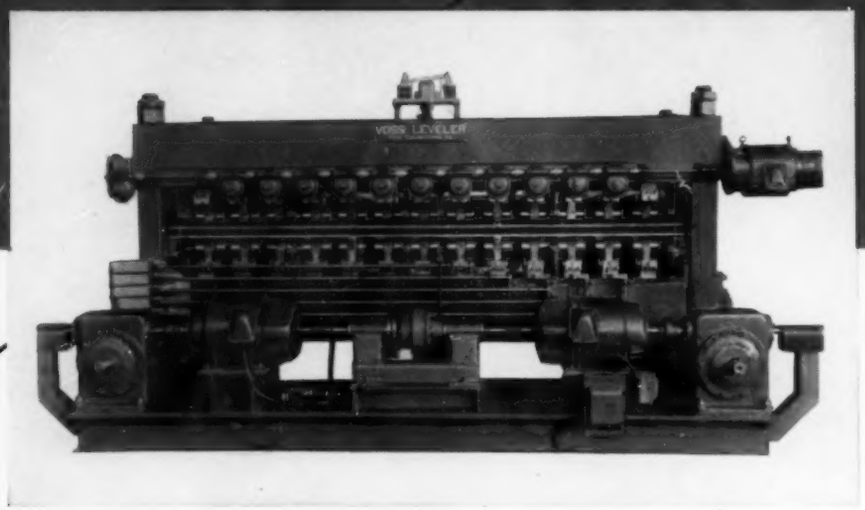
NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

How to inject exacting flatness standards into your products without slowing output from your strip or plate department



This large Voss Leveler flattens aluminum alloy tapered sheets 120" wide.

this VOSS LEVELER built by BLISS

Easy-feeding advantage has made it possible to use small Voss Levelers to flatten and stress-relieve stamped machinery parts like these.

If customer demands for dead-flat sheet, strip or plate are cutting into your production, it's time you investigated a Voss Leveler. This remarkable machine practically eliminates the leveling bottleneck by flattening material to stretcher-leveler standards at roller-leveler speed.

The machine is basically a roller leveler with long, slender, individually-driven work rolls supported by a series of short, heavy back-up rollers that maintain the longitudinal alignment of the work rolls and provide precise control of the deflections produced in the material passing through the machine.

By special arrangement with Voss Engineering Company, Bliss builds Voss Levelers to customers' requirements for flattening any of a wide range of gages and widths of ferrous or non-ferrous materials, including sheets, strip, and stamped or perforated parts. Speeds range up to 1200 feet per minute, depending on the gage and temper of the material.

So . . . if your present flattening methods aren't fast enough for you or precise enough for your more exacting customers . . . write us now for a copy of the new leaflet describing Voss Levelers and their applications.

BLISS
SINCE 1857

E. W. BLISS COMPANY, General Office: Canton, Ohio
ROLLING MILL DIVISION: Salem, Ohio
PRESSES, ROLLING MILLS, SPECIAL MACHINERY

is more than a name . . . it's a guarantee

Plants: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California
E. W. Bliss (England) Ltd., Derby E. W. Bliss Co. (Paris), France

Personnel News...

J. R. Ferguson, Jr. has been appointed an assistant vice president—engineering, United States Steel Corp. At the same time, it was announced that **P. S. Weaver** has been named to succeed Mr. Ferguson as chief engineer—project development for the corporation. Mr. Ferguson began his career with U. S. Steel in 1940 as a special engineer in the Pittsburgh general offices. He was transferred to the Chicago area in 1941 and advanced through various engineering positions until 1947 when he was named assistant works chief engineer, South Chicago Works. In 1950 he was appointed assistant to the general superintendent at that plant. In that same year, Mr. Ferguson became appropriation control and project engineer of the Orinoco Mining Co., a U. S. Steel subsidiary. One year later he was named assistant chief engineer with headquarters in New York, and in 1952 was transferred to Venezuela in the same capacity. Mr. Ferguson returned to U. S. Steel in 1954 as chief engineer—project development, the post he held at the time of his new appointment. Mr. Weaver first started with U. S. Steel in 1933 as an industrial engineer at the Clairton Works. He advanced through various industrial engineering positions in Pittsburgh District plants until 1943 when he was named superintendent—production planning at the South Chicago Works. Successively, he was named assistant to the general superintendent, superintendent—wide flange structural department, and assistant general superintendent, the capacity in which he served prior to his new appointment.

Charles E. Rice was elected executive vice president of Jessop Steel Co. He also is president and a director of Jessop Steel of Canada, Ltd., and vice president and a director of Jessop Steel International Corp. Associated with the steel industry for 34 years, Mr. Rice joined Jessop in 1943 after serving with Crucible Steel Co. of America. In 1949, he was promoted to manager of sales and in 1950 moved up to vice president in charge of sales, the position he held at the time of his present appointment.

James D. Glenn was elected vice president of sales and **Maurice J. Day,** vice president of research and development of Crucible Steel Co. of America. Mr. Glenn, formerly general manager of sales, has been associated with Crucible for the past eight years. He had been associated with the Central Alloy Steel Corp., and later with the Associated Alloy Steel Co. He also served with Sharon Steel Corp. Mr. Day began his career as a metallurgist in 1937 at Gary, Ind., with Carnegie-Illinois Steel Corp. He served as assistant director of the Armour Research Foundation in charge of program development prior to joining Crucible in 1954 as director of research and development.

William O. Bishop, formerly assistant superintendent of blast furnaces, Inland Steel Co., was made superintendent of the company's plant two blast furnaces, and **Richard J. Wilson,** formerly blast furnace engineer, was made assistant superintendent.

Jack J. Carlson has been appointed a vice president of Kaiser Steel Corp., and general manager of the Montebello, Calif., Fabricating Division plant. **B. J. "Barney" Osborne,** present general manager of the plant, will move to the Oakland home offices of the company as assistant to the vice president and general manager for consultation in connection with Kaiser Steel's Fabricating Division operations. Mr. Carlson joined Kaiser Steel in 1944 as administrative assistant, following four and one-half years with Inland Steel Co. He was successively district sales manager for the Kaiser Steel's offices in Seattle and Los Angeles, and was later appointed assistant general sales manager in the Oakland home office. In 1951 he was named general sales manager, and in 1954 became assistant to the vice president and general manager.

Robert G. McCoy has been named plant industrial engineer of the Ferndale plant of the Steel and Tubes Division of Republic Steel Corp. near Detroit. He succeeds **William J. Nelson,** who has been appointed to the position of methods engineer at the general office of the corporation. He is now on special assignment to the Truscon Steel Division of Republic, in Youngstown, Ohio.

John D. Sutherland was named to the newly created position of assistant division superintendent of

J. R. FERGUSON, JR.

CHARLES E. RICE

JAMES D. GLENN

MAURICE J. DAY

WILLIAM J. WALLACE

G. S. CRANE

PHILIP RYAN

EDMUND SHUSTER

steel producing at the Fairless Works of United States Steel Corp. Mr. Sutherland comes to the Fairless Works from U. S. Steel's Youngstown District (Ohio) Works, where he started his career in 1940 as a metallurgical observer. Mr. Sutherland transferred to the open hearth department in 1946 as a pit foreman. Advancing through a successive series of steps in the steel producing department, he was appointed acting superintendent of the open hearth department in September, 1955, the position he held until his present appointment.

William J. Wallace, formerly with Rotary Electric Steel Co., is now with Northeastern Steel Corp., Bridgeport, Conn., as assistant superintendent of mills and roll designer.

G. S. Crane, president and chief executive officer of Cutler-Hammer, Inc. since 1945, was elected chairman of the board and chairman of a newly-created plans committee, effective January 1. He will succeed **H. F. Vogt,** who is resigning as chairman after 56 years with the company. **Philip Ryan,** vice president in charge of manufacturing since 1945 and a director since 1949, was elected president and chief executive officer to succeed Mr. Crane. **J. C. Borden,** comptroller since 1947, was elected vice president and comptroller. Mr. Vogt will continue as a member of the board of directors. He has been chairman since 1949. Mr. Crane was elected a director in 1931 and vice president in charge of sales in 1935. In 1939 he became vice president in charge of sales and engineering.

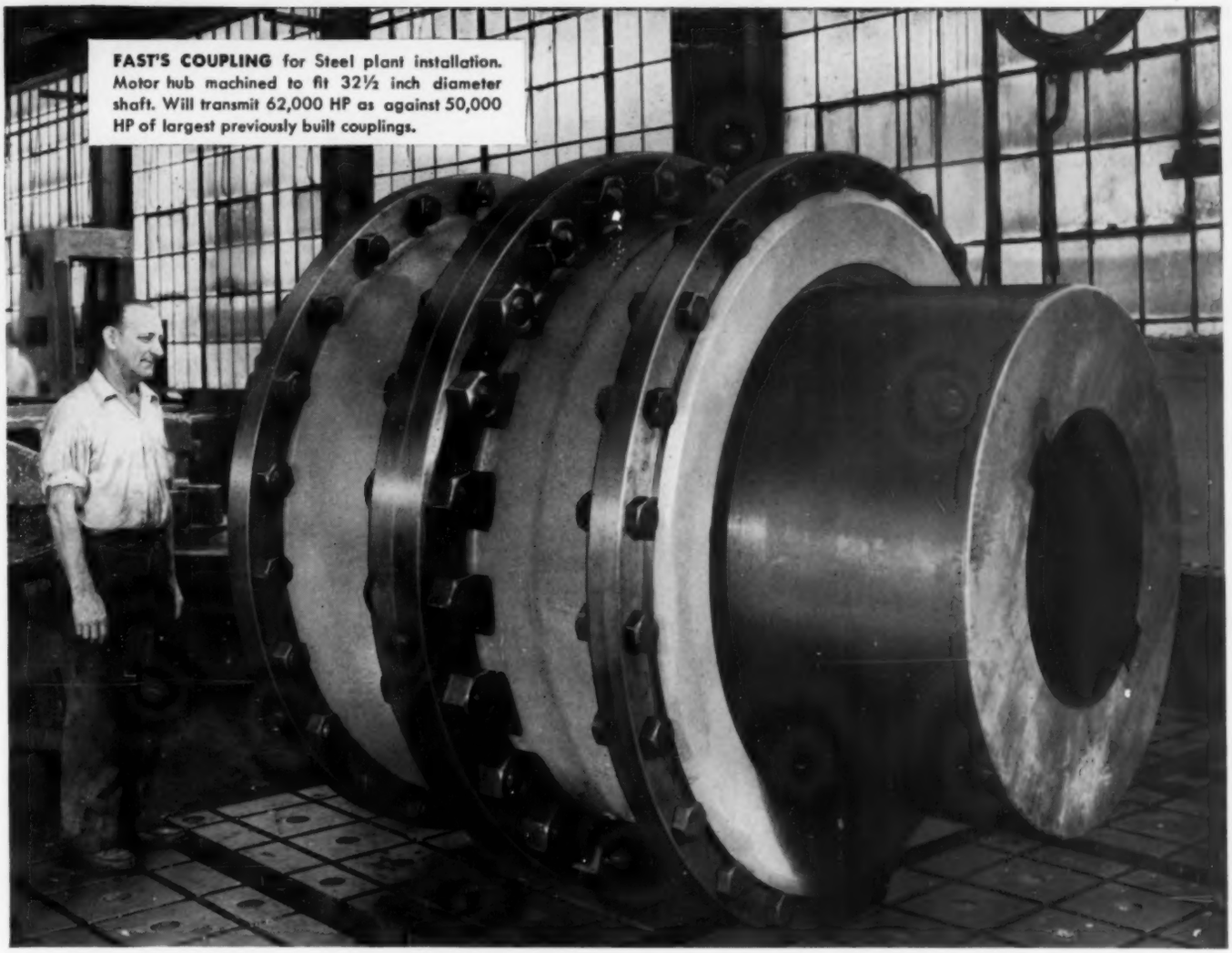
Edmund Shuster has been appointed chief European sales engineer for E. W. Bliss Co.'s Rolling Mill Division, replacing the late **D. H. Montgomery.** From headquarters at the Bliss French subsidiary in Paris, he will direct sales and service engineering for rolling mills and allied equipment as well as mill rolls and tube straighteners for Bliss' Mackintosh-Hemphill Division. Prior to this assignment, Mr. Shuster had been actively engaged in planning, production and project engineering for the Rolling Mill Division since the end of World War II. Most recently, he was active in coordinating and directing heavy equipment projects at Bliss' Rolling Mill plant.

Richard H. DeMott, now chairman of the board and president of SKF Industries, Inc., will relinquish the post of president, effective January 1. He will continue to serve as board chairman. **Edwin R. Broden,** now executive vice president, will succeed Mr. DeMott as president and chief executive officer. Mr. Broden, who joined the SKF organization earlier this year was formerly executive vice president and a director of the Carborundum Co., and division manager for Blaw-Knox Co.

Paul C. Ford has been appointed chief engineer of Wagner Electric Corp.'s Electrical Division to succeed **C. P. Potter** who is retiring after more than 46 years with the Wagner organization. Mr. Ford joined Wagner in 1937 as a student engineer. He worked for some years in the distribution and power transformer engineering sections, and was named supervisor of the unit substation and dry-type transformer engineering section in

PAUL C. FORD

1950. In 1953 he was made assistant manager of Wagner's Transformer Engineering Division, serving in that capacity until appointed to his present position. Mr. Potter, who will remain with Wagner Electric in a consulting capacity until the first of the year, joined the company as a student engineer in June, 1909. Through succeeding years he served in a number of key engineering positions and for the past nine years has been chief engineer of the Electrical Division.



FAST'S COUPLING for Steel plant installation. Motor hub machined to fit 32½ inch diameter shaft. Will transmit 62,000 HP as against 50,000 HP of largest previously built couplings.

WORLD'S LARGEST INDUSTRIAL GEAR-TYPE COUPLING

To make a coupling that will transmit 62,000 HP and compensate for errors in alignment . . . that's more than a man-sized job.

But Koppers took on the project and this Fast's Self-Aligning Coupling is the result.

After six months of machining and assembly, this huge, *all metal* coupling is on its way to installation in a Milano, Italy, steel mill where it will carry power to a Mesta, 110-inch, four-high reversing plate mill.

It will transmit power from an electric motor to the equipment, and, at the same time, compensate for shaft misalignment and lateral float, give maximum power transmission efficiency, eliminate breakdowns and costly down-time.

WHAT'S YOUR COUPLING PROBLEM?

This mammoth Fast's Coupling is just one example of the outstanding jobs which Koppers is equipped to handle. 35 years of manufacturing "know-how" go into the production of *all* Fast's Couplings, large and small alike. Engineering specialists, experienced in designing Fast's Couplings for special applications, are well equipped to solve your coupling problems.

Remember, there's a Fast's Coupling for every power transmission application. Next time you have a coupling problem, call on Koppers . . . always ready to serve you. No obligation, of course. Also, for full details on Fast's Couplings for industry, mail this coupon.

THE ORIGINAL **Fast's Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

Engineered Products Sold with *Service*

KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* **312 Scott St., Baltimore 3, Md.**

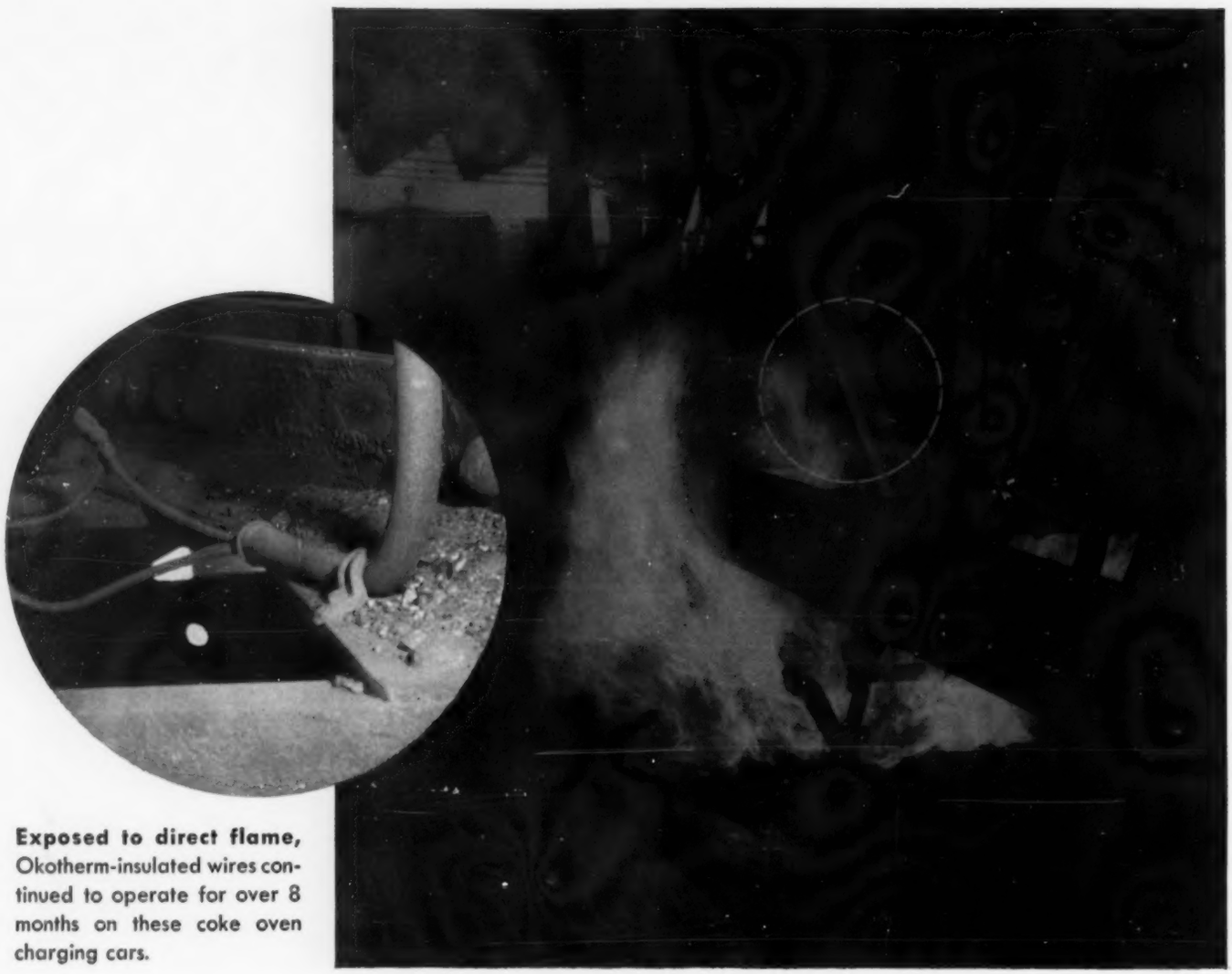
Gentlemen: Send me FREE, Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....



Exposed to direct flame, Okotherm-insulated wires continued to operate for over 8 months on these coke oven charging cars.

Okotherm-Insulated Wires lasted 8 months here

Until recently, one of the nation's largest commercial coke producers in the southeast had to replace at least one cable leading to the vibrators on its coke oven charging cars "*every shift, three shifts a day, thirty days a month.*"

These replacements were necessary because the cables had to pass through flames toward the end of each charging operation. The company reported that this replacement cost them an average of $247.50 a month.

Eight months ago, they installed Okotherm-insulated wiring on the vibrators and lights of these cars. Since that time, no replacements have been required. The total wire and installation cost was less than $200. The "per month cost" already averages less than $25.00.

If you have a high ambient temperature cable problem, it will pay you to investigate Okotherm-insulated cables. Suitable for operation up to 200C, Okotherm-insulated cables are moisture- and ozone-proof and have high dielectric strength. Single and multiple-conductor power and control cable constructions are available.

NEW— Okotherm-insulated cable *with aluminum sheath.* Eliminates conduit. New Bulletin IS-1088 gives all details. Write for it today to The Okonite Company, Passaic, N. J.

OKONITE SINCE 1878 *insulated cables*

2953

Joseph J. Kochelek has been named application engineer for the Century Electric Co. He succeeds **J. T. Ryan** who is retiring after 38 years of service.

A. F. "Frank" Scarr has been appointed assistant to the vice president and general manager of Kaiser Steel Corp. He assumes the position left vacant by the appointment of **Jack J. Carlson** as vice president.

Dr. Harry L. Bishop, Jr. has been appointed development Engineer—process metallurgy in the Technical Services Division of Jones & Laughlin Steel Corp.

Richard F. Trimbach, was appointed manager, new product development of Loewy Construction Co., Division of Baldwin-Lima-Hamilton Corp.

Ward W. Clarke, former chief engineer, has been appointed vice president in charge of engineering, S P. Kinney Engineers, Inc. **Hugh B. Carr** replaces Mr. Clarke as chief engineer. Mr. Carr was formerly with the Steel Co. of Canada, Ltd.

Harold J. Coleman has been appointed sales manager of Chandeysson Electric Co. Before joining Chandeysson, Mr. Coleman was a district manager for Essex Wire Corp. Prior to that he was associated with General Electric Co.

John A. Baldinger, who has been serving since 1951 as general manager of the Automatic Transportation Co., Division of Yale & Towne in Chicago, has been appointed general manager of the Yale Materials Handling Division in Philadelphia, succeeding **Elmer F. Twyman,** vice president, who had acted also as general manager. Mr. Twyman will now make his headquarters at the corporate executive offices in New York.

Albert E. Martz has been appointed staff industrial engineer, Industrial Engineering Department, Jones & Laughlin Steel Corp. **Robert C. Witney** has been appointed division industrial engineer—Container Division.

H. J. Marty was named district manager of the Ohio Knife Co.'s New York office. His territory will include the states of N. Y., N. J., the eastern half of Pa., and all of New England. Formerly affiliated with Ohio Knife's Detroit, Mich., office, Mr. Marty has, for the past ten years been assistant manager of the New York office. **Robert Douglas,** formerly manager of the New York office is retiring from active service, but will still retain his position as secretary of the company.

Roger A. Nagan has been promoted to superintendent of coke ovens for Interlake Iron Corp.'s Duluth plant. He has been a coke oven foreman since 1953.

John M. Anspach has been appointed manager of the foundry and pattern shop of the De Laval Steam Turbine Co. He was formerly service engineer with the Meehanite Metal Corp.

Stephen M. Jenks, assistant executive vice president—operations, U. S. Steel Corp., will receive the Benjamin F. Fairless Award for distinguished achievement in iron and steel production and ferrous metallurgy. The citation reads, "for his outstanding accomplishment and leadership in increasing production in his company and in the industry." This is the second annual Fairless Award made by the American Institute of Mining and Metallurgical Engineers. Actual awards will be made at the annual meeting of the Institute in New York in February, 1956.

Charles T. Schwarz has been appointed Chicago branch sales manager by the Yale & Towne Manufacturing Co. He replaces **Roy L. Wolter** who was recently appointed general manager of the Yale & Towne Automatic Transportation Co. Division in Chicago.

S. D. Payzer, vice president in charge of engineering since December, 1954 was elected member of the board of directors of the D. J. Murray Manufacturing Co. He fills the vacancy created by the death of **D. C. Everest.** Mr. Payzer has been with D. J. Murray since 1923 when he joined the company as designing engineer. In 1926 he was promoted to position of chief engineer, and last year was elected vice president in charge of engineering.

Robert W. Wyman has been appointed manager of the Youngstown, Ohio, branch office of Kaiser Aluminum & Chemical Sales, Inc. In his new post Mr. Wyman

RICHARD F. TRIMBACH

WARD W. CLARKE

HUGH B. CARR

HAROLD J. COLEMAN

will be responsible for the sale of Kaiser Aluminum products in the Youngstown area. He previously had served as salesman at Kansas City, New Orleans and St. Louis.

Thomas E. Peacock, Jr. has been named manager of market research, Exide Industrial Division of the Electric Storage Battery Co.

John D. Horth has been appointed assistant manager of the Compressor Sales Department at De Laval Steam Turbine Co. Mr. Horth joined De Laval in 1947. He served in the Chicago sales and service headquarters until 1949, when he was named district manager of the St. Louis office. In 1951 he was transferred to the Compressor Sales Department in Trenton.

Donald C. Altman, a sales representative in Allis-Chalmers Seattle district office for the last 10 years, has been appointed manager, Industries Group, Allis-Chalmers Great Britain, Limited.

E. C. Tinsley was named to the position of vice president in charge of refractory specialties of Mexico Refractories Co. **Halfred F. Randolph,** formerly assistant manager, is manager of the Refractory Specialties Division of the company.

Richard Smucker has been appointed project engineer with the E. W. Bliss Co. Rolling Mill Division.

RICHARD SMUCKER

Prior to this appointment Mr. Smucker served as an engineer in the Salem, Ohio, plant. Before that he was sales manager of Kane and Roach inc.

Charles H. Luikart has been appointed assistant district sales manager of the Cleveland district office of Kaiser Aluminum & Chemical Sales, Inc. Before his promotion Mr. Luikart was manager of the Boston branch office.

George E. Swift, formerly Philadelphia district manager for Electric Machinery Mfg. Co., has been promoted to a newly created position as special representative of the company. He will continue to have his offices in Philadelphia. Mr. Swift joined the company 32 years ago. He became Philadelphia District Manager in 1928. **Clinton G. Smith** has assumed the duties as district manager. **Norman G. Selland,** formerly of the Buffalo, N. Y., office of Electric Machinery, has assumed sales engineering duties in the New York City office. **Robert O. Bresee** succeeds Mr. Selland in the Buffalo territory.

Daniel J. Girardi has been appointed to the post of metallurgical engineer in charge of research and

DANIEL J. GIRARDI

process control at the Timken Roller Bearing Co. Mr. Girardi will direct metallurgical research and mill metallurgical work for all divisions of the company.

Donald W. Games has been appointed sales engineer for Production Machinery Corp. Mr. Games was formerly a project engineer with Wean Equipment Corp.

H. E. Boedecker has been appointed superintendent of electrical and mechanical maintenance, Northeastern Steel Corp. In addition, **K. W. Whitney** has been named chief electrician and **C. A. Wiebe, Sr.,** assistant superintendent of maintenance—mechanical division.

Obituaries

Roy A. Lewis, retired general manager of Bethlehem Steel Co., Bethlehem, Pa. plant, died November 17 at the age of 78. He had been employed by Bethlehem since 1907, becoming general superintendent of the Bethlehem plant August 28, 1917. The title was changed to general manager in 1924. He retired in 1945.

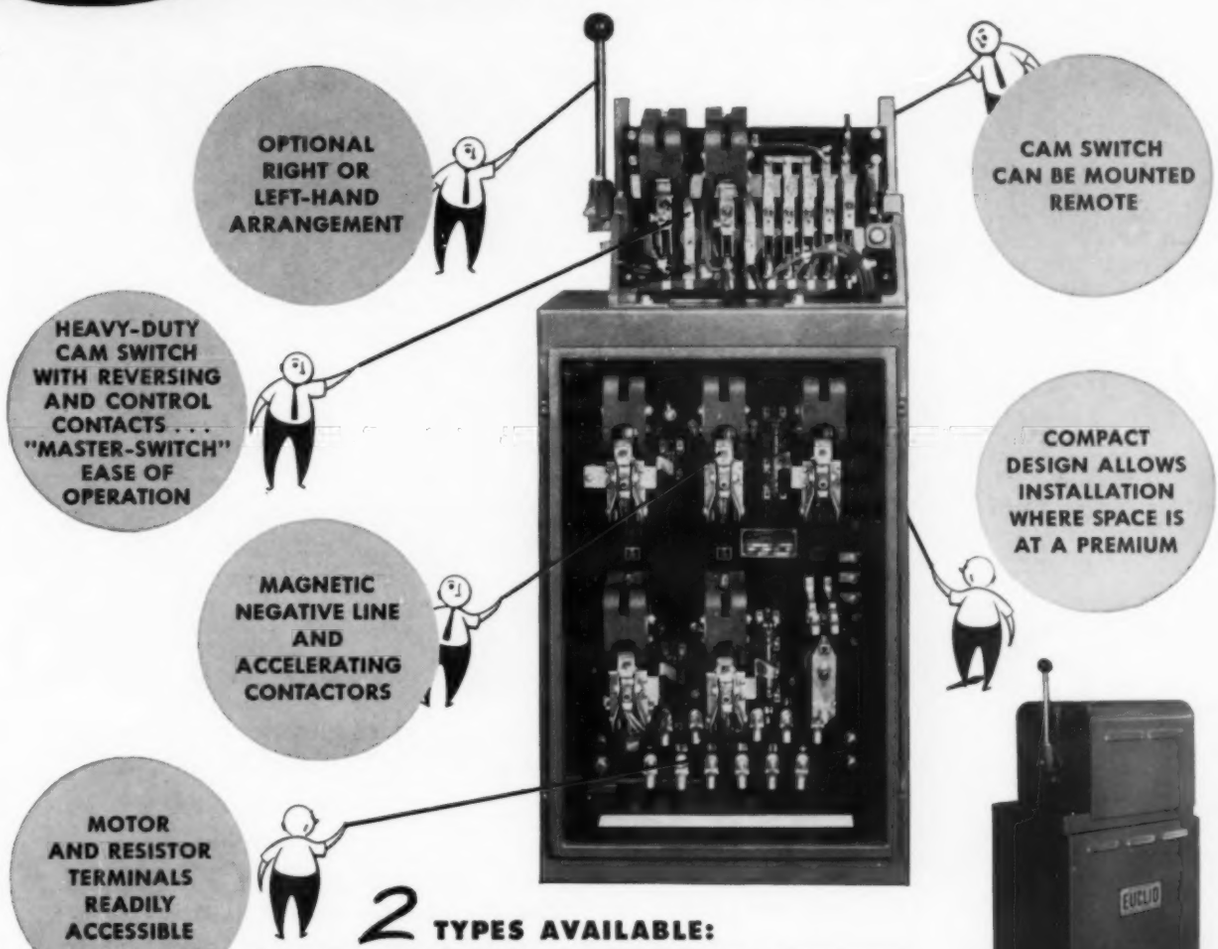
Charles F. Feledy, 63, development engineer for Armco Steel Corp., died November 22. He joined Armco in 1926, as assistant metallurgist at the company's Butler, Pa., Works. In 1928, he was made assistant chief metallurgist at the Butler plant. In 1953 was appointed a development engineer in the company's market development division.

Ralph J. Knerr, superintendent of the alloy and tool steel division, Bethlehem plant of Bethlehem Steel Co., died November 23. Mr. Knerr had headed the division since 1946.

NEW

HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

Combination Manual and Magnetic Controller for Cranes . . . Charging Machines . . . D-C Control Jobs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COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM
MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS
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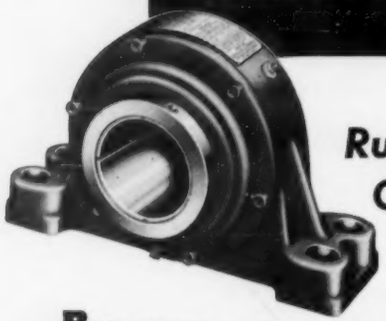

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New TM ALLOY STEEL downtown

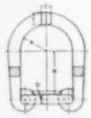
MAGNET CHAIN

lasts 5 to 15 times longer than conventional types!

- Locating plate keeps legs at 120° centers—eliminates wear—increases life of assembly!
- Made of Taylor Made Alloy Steel Chain—has twice the tensile strength of wrought iron.
- Resistant to shock, grain-growth, work-hardness.

Patent No. 2626175

Locating Plate takes larger joiner links with squared top sections—keeps chain legs separated at 120° centers to reduce friction, twisting and gouging.



New Lifting Bail provides larger opening for hook. Heavy, squared-type Alloy Steel construction assures longer life.

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MEASURES THICKNESS ACCURATELY *without TOUCHING the MATERIAL*

Hot or Cold Strip Steel, Brass, Copper, Aluminum . . . Plastics, Foils, Coated Fabrics, Film, Rubber, Etc., Even When Moving At High Speed.

Simple method—the "Measuray" shoots X-Rays through the material—measures its absorption of the rays. Calibrated meter registers plus or minus per cent of deviation from pre-determined standard. Especially useful on hot mills where material can't be checked by contact gages. Also when material can be deformed by contact such as foil.

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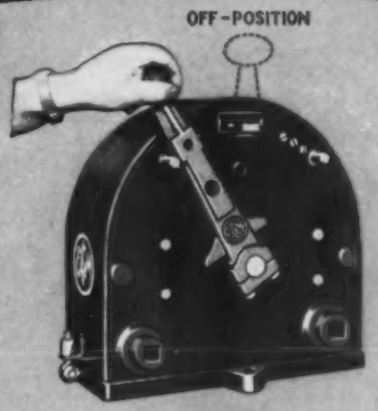
Here's Where EC&M CONTROL Gives Unexcelled Results

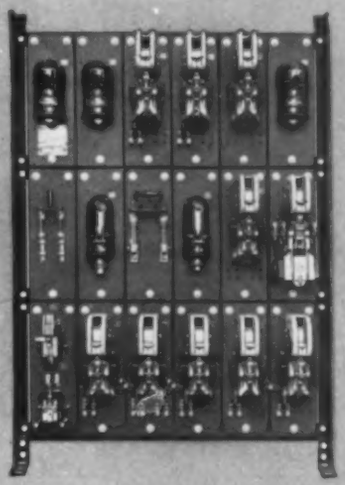
The EC&M Wright Dynamic Lowering Circuit Controller for crane-hoists is well known for its ability to permit accurate, short movements when spotting a load. The operator has complete control of all lowering speed-points. In setting the cope with this 125-ton crane, quick response through fast brake release enables the operator to close the mold carefully—with a minimum number of movements which maintenance men recognize as a contributing factor to reduced up-keep. The Wright Circuit is safe—specify EC&M Crane Control.

WRITE FOR BULLETIN 921

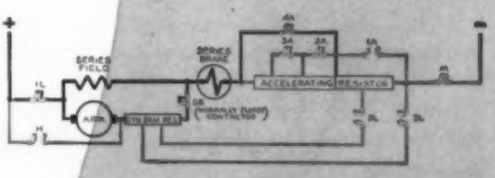
Photo—Courtesy, Cleveland Crane & Engineering



Speed-control Master Switches have short throw—narrow width—and are convenient for the operator to use.



The Wright Dynamic Lowering Circuit Controller (with protection) for crane-hoists.



First point lowering connections put all the current from the line through the brake for fast release.

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THE ELECTRIC CONTROLLER & MFG. CO.

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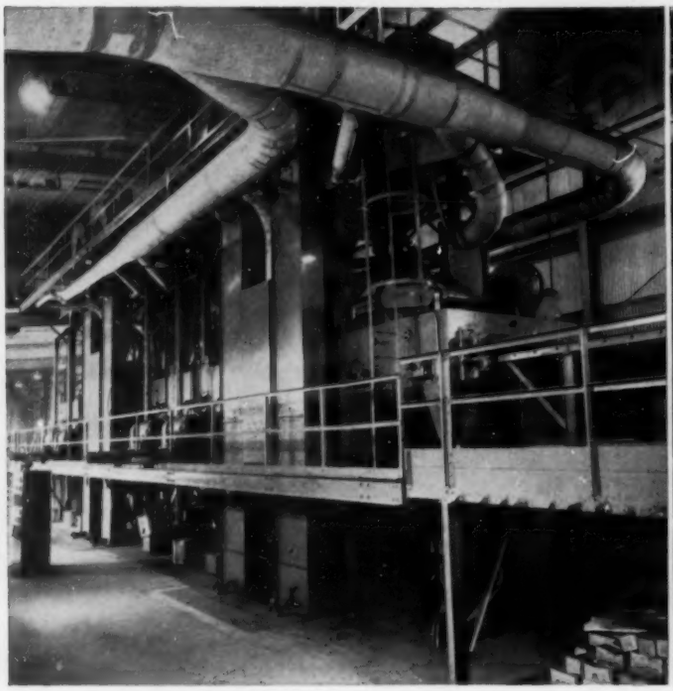
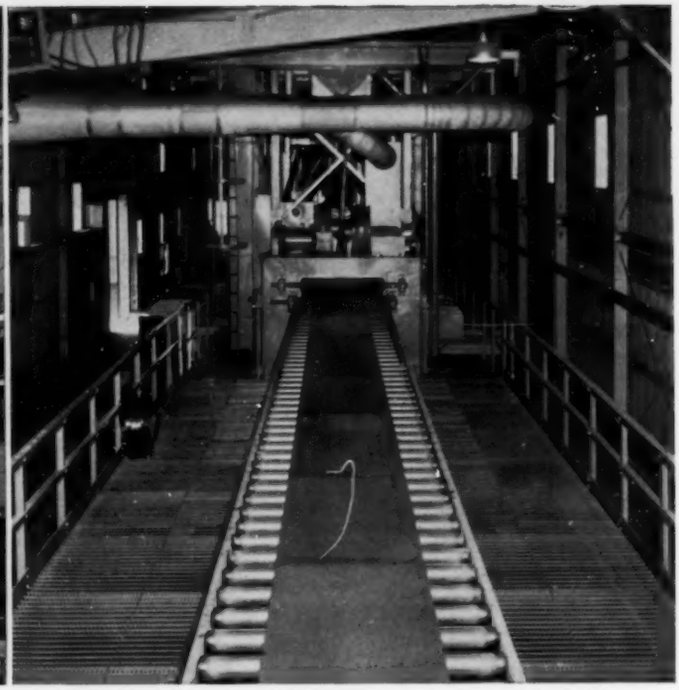
EMPIRE STEEL'S NEW CARBON STRIP LINE





CARBON STEEL STRIP MECHANICALLY CLEANED FOR THE FIRST TIME...

in the world's largest mechanical descaler

The first application of mechanical blast descaling to carbon steel strip in a producing mill has brought significant savings in time, space and expense.

A 16-wheel Wheelabrator cabinet installed at Empire Steel Corporation in Mansfield, Ohio, cleans 250′ to 300′ of carbon strip a minute and has eliminated all pickling except a 10 to 13-second immersion in a flash-pickle tank only 60′ long.

The Wheelabrator is 66′ long and accomplishes cleaning that would require approximately 250′ of tanks for straight pickling. In addition to saving space, the blast descaling equipment has speeded cleaning and eliminated at least 75% of the acid required. This serves to reduce acid disposal problems and tank maintenance requirements.

Cold mill operators report the matte finish imparted by Wheelabrating also enhances the cold working properties of the metal.

Wheelabrator blast descaling equipment, which can be designed to handle strip at rates up to 600′ a minute, is the answer to faster production for new or existing lines. In the latter, Wheelabrator blast descaling gives increased cleaning production without requiring additional floor space.

For more information on Wheelabrator blast descaling principles and savings, send today for Bulletin 864.

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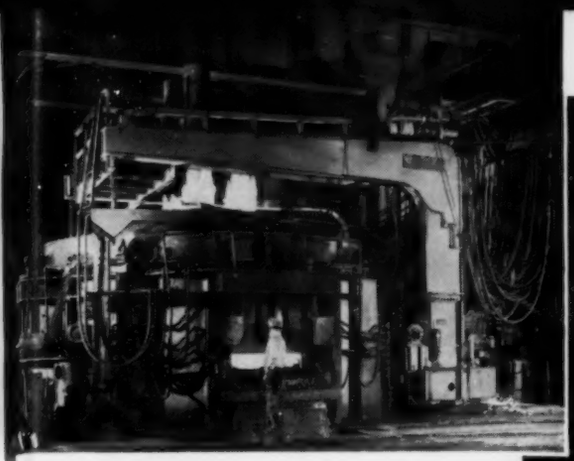
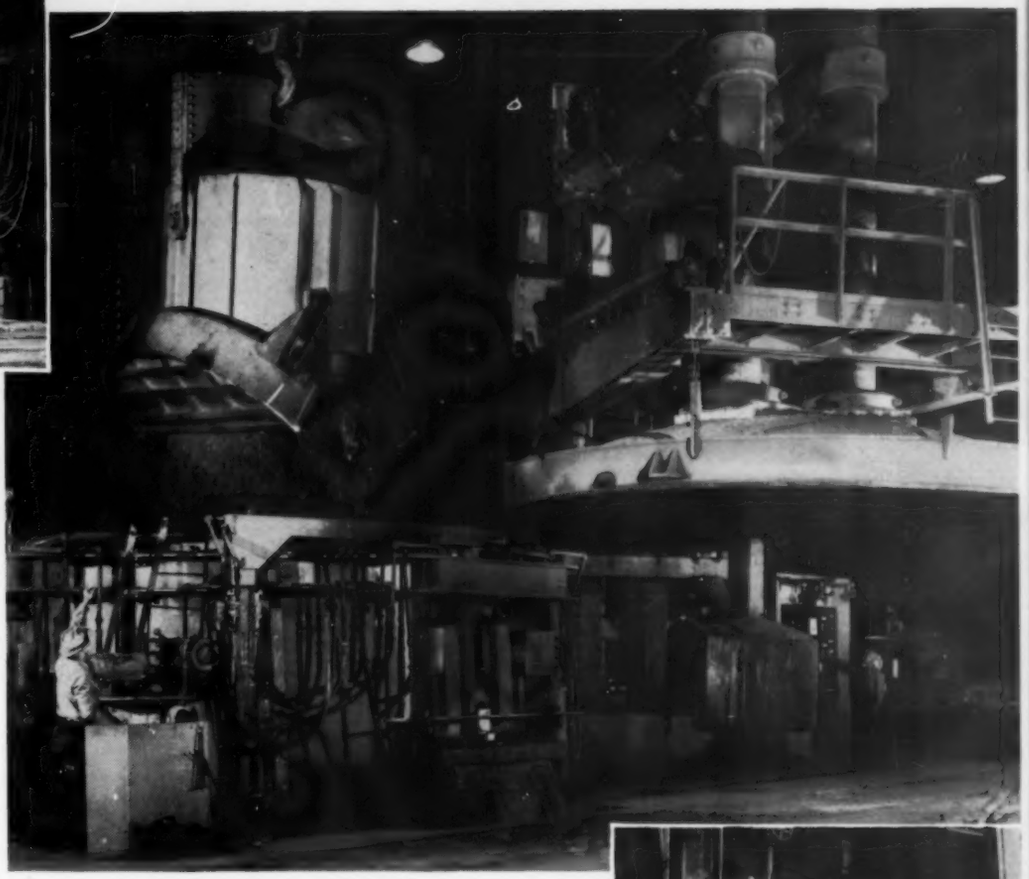
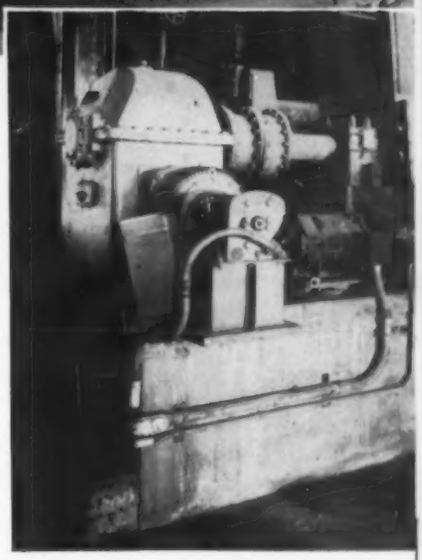




Shown above is a 20′ diameter shell Top-Charge Heroult Furnace. At right, the same furnace is shown with swing-type roof removed for charging. Smaller picture at lower right, shows tilting mechanism for 20′ diameter Heroult.



Heroult Electric Furnaces for faster, high quality steel making - -

To keep pace with modern steel making methods . . . to produce better quality steel faster, and more economically, it will pay you to consider the addition of electric furnaces to your existing facilities.

In the light of the experience of some of the nation's most successful mills, Heroult Electric Furnaces should easily prove a big time and labor saver, *and quality up-grader* for you.

Embodying the latest in mechanical and electrical equipment, these widely used furnaces are noted for their efficient performance, and low operating and maintenance costs.

Available in sizes of shell diameter ranging from 7′0″ up to 24′6″, and with rated charge capacity of from 8000 lbs. up to 400,000 lbs. They are usually equipped with roof-moving mechanism to permit top charging. Both gantry and swing-type roof-moving mechanisms are available. Door-charging furnaces and furnaces of special design, including units equipped with austenitic steel bottoms to permit inductor stirring, can also be supplied.

We welcome an opportunity to help you select and install the Heroult Electric Furnace best suited to your particular requirements.

THIS CATALOG

contains up-to-date information on Heroult Electric Furnaces — types, sizes, capacities, rating, etc. For free copy, write to our Pittsburgh office.

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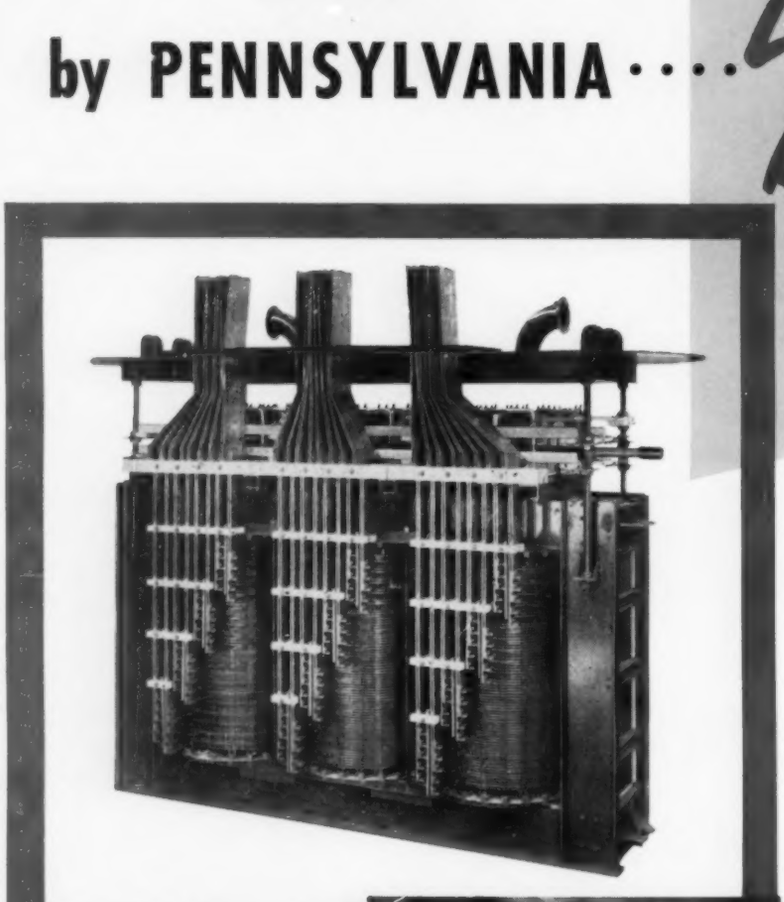
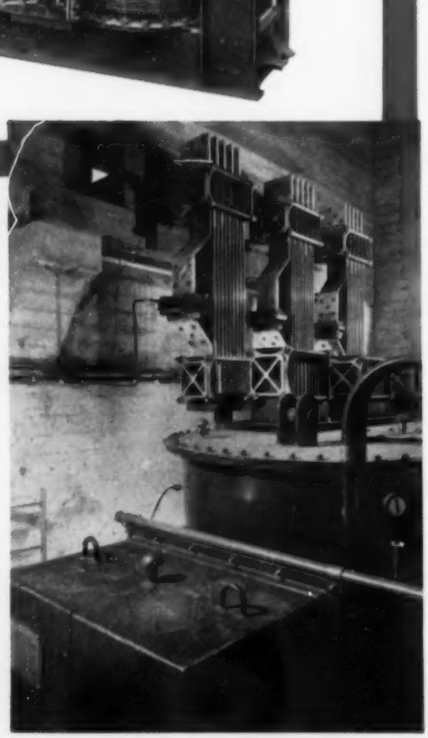
UNITED STATES STEEL

A Furnace Transformer Record by PENNSYLVANIA ....

No Low Voltage Breakdowns in 20 years



Low voltage side of a 25,000 Kva Pennsylvania Furnace Transformer. Three phase, 60 cycles, water-cooled. High voltage: 13,800 volts. Low voltage: 430 to 290 volts. Maximum line current 39,000 amps.



18,750 Kva Pennsylvania furnace transformer in service at a West Coast steel plant. Three phase, 60 cycles, forced-oil/water-cooled. High Voltage: 6600 volts. Low Voltage: 375 to 144 volts. Maximum line current: 33,300 amps.

In 1936 Pennsylvania introduced a new type of helical winding in the low voltage coils of a 2500-kva furnace transformer. Since then, the same principles of coil design have been incorporated in scores of Pennsylvania furnace transformers. These furnace transformers have ranged in size from 250 through 25,000 kva, and from 3175 through 57,735 amps.

This wide range of sizes demonstrates Pennsylvania's complete familiarity and experience with furnace transformer application. Even more important, however, is the record of performance achieved over this entire range — a 20-year record which reveals that there has **never been a low voltage breakdown** on any Pennsylvania furnace transformer utilizing the exclusive helical coil design.

With a background such as this, in both experience and **proved performance,** Pennsylvania Transformer Company is well qualified to satisfy today's highly exacting furnace transformer requirements. Whether you buy your next furnace transformer separately or as part of an installation "package", why not make certain of long-range dependability by specifying Pennsylvania?

PENNSYLVANIA TRANSFORMER COMPANY

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DECEMBER, 1955

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Note: Post cards expire three months after publication date.

(1) Hardness Chart

A chart which shows the approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels has been issued recently by the Tubular Products Division of the Babcock & Wilcox Co. The hardness systems covered are brinell, monotron, vickers, and rockwell (B, C and E scales).

(2) Magnetic Drive

A new precision drive for adjustable speed applications is described in a bulletin published by Electric Machinery Manufacturing Co. The four-page folder explains use of the drive for both fan-type (centrifugal fans, pumps, compressors) and constant torque loads (conveyors, mixers, machine tools, etc.). Construction features are illustrated clearly. Pictorial drawings show the relationship of the drive to its magnetic amplifier control, the driving motor and driven load. The folder lists many advantages obtained by means of this source of speed control, and gives detailed information on hp ratings, speed ranges, and speed control precision for both variable torque and constant torque loads, and also shows important dimensions. (Bulletin No. 4400-PRD-229)

(3) Lubrication

The Farval Corp., has recently published a 20-page booklet describing its centralized systems of lubrication. Complete with illustrations, the booklet explains how Farval valves operate. Also described and thoroughly illustrated are central pumping stations, spray valves, and fittings and accessories. (Bulletin No. 26-R)

(4) Testing and Balancing Machines

A special 75th anniversary brochure traces the development of modern testing and balancing machines by the Tinius Olsen Testing Machine Co. The major advances in design of testing and balancing equipment since the first truly universal testing machine was developed by Tinius Olsen in 1880 are described as a background for the understanding of present and future developments in the testing industry. The Olsen 60,000 lb capacity de Luxe super "L" is illustrated with some of its most commonly used instruments and accessories, showing versatility and adaptability to a wide range of testing needs of the modern universal testing machine. Application of electronics for weighing and recording test results (the new selectorange indicating system) and greater simplicity and accuracy of operation are explained. Developments in balancing equipment are illustrated, including the new automatic crankshaft balancers.

(5) Trackmobile

A recently published 16-page broadside that gives full details on their new freight car mover that operates on railroad track or road is available from the Whiting Corp. It contains many in-use photographs of the new trackmobile hauling, spotting and switching cars and gives engineering information, explanations and illustrations of features. It also explains the trackmobile's unique method of gaining traction for handling many loaded freight cars, and its method of automatically converting to rubber-tired wheels for operation across unimproved track and on roadways. (Bulletin T-115)

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54	ASKANIA REGULATOR CO.	BULLETIN 161	Edge position control.
55	ATLAS CAR & MANUFACTURING CO.	BULLETIN 1283	Transfer cars.
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61	BUFFALO FORGE CO.	BULLETIN FM-1234	Heavy-duty propeller fans.
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67	ELECTRIC CONTROLLER & MANUFACTURING CO.	BULLETIN 921	Dynamic lowering circuit controller.
68	ELLIOTT CO.		Mill motors.
69	ENTERPRISE CO.	BULLETIN 502	Friction sawing.
70	EUCLID ELECTRIC & MFG. CO.	BULLETINS 4400-4401	Heavy-duty d-c controllers.
71	FOOTE MINERAL CO.		Steel additives.
72	GEAR GRINDING MACHINE CO.		Constant velocity universal joints.
73	GENERAL ELECTRIC CO.	BULLETIN GEC-1319	General purpose recorder.
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78	PANGBORN CORP.	BULLETIN 1210	Blast cleaning.
79	PITTSBURGH LECTROMELT FURNACE CORP	CATALOG NO. 9 and CATALOG NO. 105	Melting furnaces and furnaces for smelting.
80	ROCKBESTOS PRODUCTS CORP.	SPECIFICATION RSS-88	Construction and test specifications of rockbestos.
81	RUST FURNACE CO.		Furnace information.
82	STEARNS MAGNETIC, INC.	BULLETIN 35-C	Lifting magnets.
83	UNITED STATES GRAPHITE CO.		Brush catalog.
84	WAGNER ELECTRIC CORP.	BULLETIN MU-203	Fan-cooled motors.
85	JOHN WALDRON CORP.	BULLETIN 55-1	Couplings.
86	WHEELABRATOR CORP.	BULLETIN 864	Blast descaling principles.
87	LEE WILSON ENGINEERING CO., INC.		Annealing furnaces.

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IRON & STEEL ENGINEER

1011 EMPIRE BUILDING

PITTSBURGH 22, PA

IRON & STEEL ENGINEER

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73	74	75	76	77	78	79	80	81	82	83	84	85
87												

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DEPARTMENT _____

COMPANY _____

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*INQUIRIES FOR ITEMS LISTED IN THIS ISSUE NOT VALID AFTER APRIL 1, 19

Oil Immersed

mechanically interlocked power outlet

Type 620-A-3GX Safety Switch with Receptacle and Plug Interlock—Closed View and with Oil Tank Lowered Showing Arrangement of Component Parts

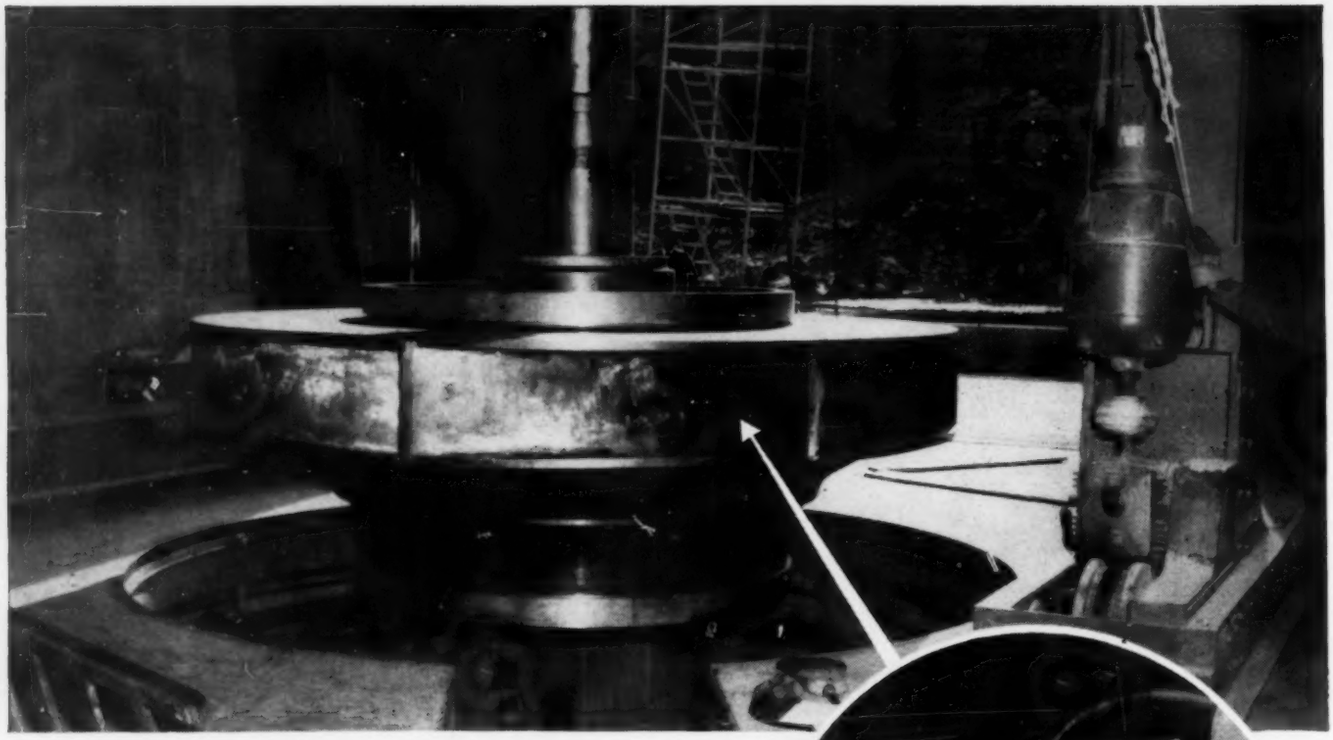
A safety power outlet to provide dependable operation under adverse conditions and convenience for readily connecting portable equipment such as welding machinery, conveyors, mixers, agitators, etc. Manually operated, mechanically interlocked switch handle and plug makes it impossible to insert or remove the plug while the switch is in the closed position.

Standard features of the Rowan Type 620-A-3GX Safety Switch include the following: completely oil immersed; manually operated disconnect switch of the quick-acting contactor type with renewable contacts; equipped with ROWAN time-tested AIR-SEAL fuses; sealed-off terminal compartment; safety disconnect jack; straight through conduit entrance; provision for padlocking switch in the OFF position; enclosure designed to meet the requirements of NEMA Type XI — also available for NEMA Type VIII, Class 1, Group D locations, designated Type 620-A-1-3GX.

Complete information available from Rowan representatives in principal cities of the United States.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.



Sigma welding has made the repair of these large pump impellers faster and more economical. Finished welds are a sound, homogeneous bond.

Sigma Welding Saves $5,000 per unit

Speeds repair of world's second largest pumps . . .

During operation, giant 20 ton manganese bronze pump impellers like this one, suffer cracks ranging in size from small sand inclusions, to cuts over a foot long. By using sigma welding, it is now possible to make high quality, on the spot repairs without disassembling the units — this results in an immediate savings of 5,000 dollars per pump.

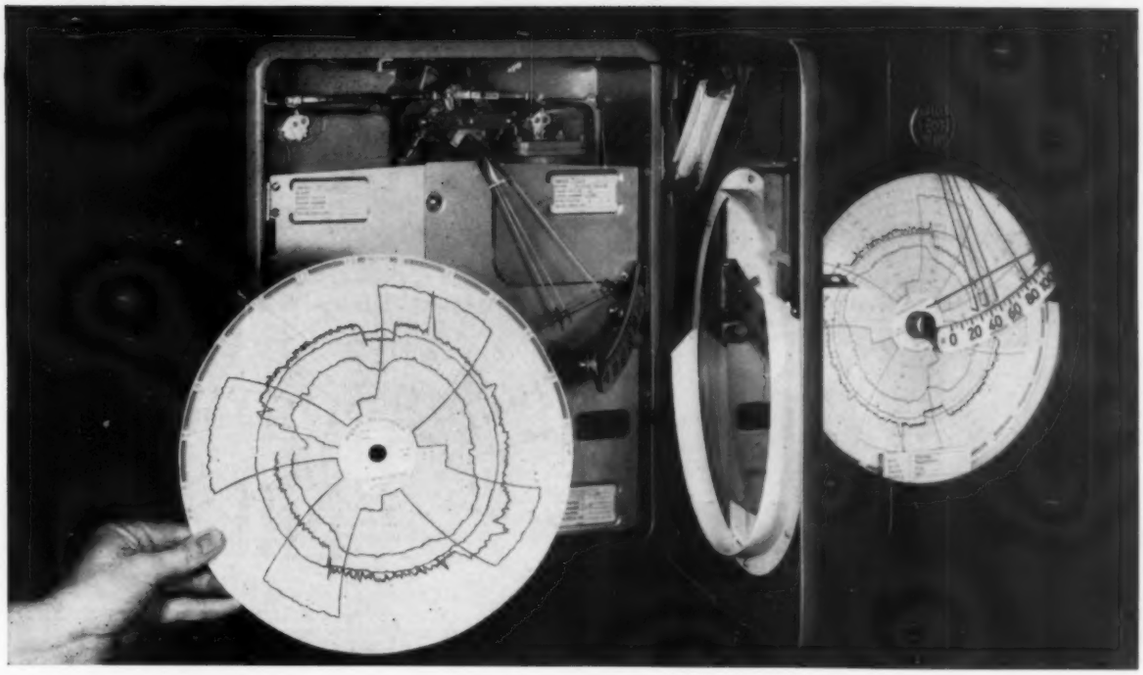
Shown above is a typical repair operation on one of the 22,000 hp. electric motor driven pumps. This crack is 11-in. long, 2½-in. wide, and 2-in. deep. The four pegs adjacent to the crack are strain check points. Frequent measurements made of the distance between them determines welding duration and the peening sequence necessary to control distortion which in this operation was less than 0.005 inch. The completed weld made with aluminum bronze wire has an excellent surface appearance and color match.

You can speed production and cut costs in your operations—find out more about sigma welding from your local LINDE representative . . . Start saving now, call him today.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto
(formerly Dominion Oxygen Company)

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark



Faithfully yours –

Clear, Continuous Records without Poisoning . . . on the New Bailey Recorder

★ Faithful chart records of measured variables are the key to a meaningful, dependable analysis of operating trends and conditions. Money spent for more accurate metering, for faster response, is money down the drain—*unless* it's matched with chart records that are equally accurate.

That's why these features of the new Bailey Recorder are important to you:

1. Bailey's exclusive sealed capillary-action inking system maintains continuous flow to the pen tip, and traces sharp, opaque, quick-drying records. "Poisoning" of intersecting records is practically eliminated; no blots or smears during operation or chart changing.

2. Pens are mounted on concentric centers, trace on parallel time arcs only 42/1000" apart. This simplifies analysis of two or more records.

3. Interchangeable plug-in receiver units permit practically limitless record-grouping combinations.

Write for Product Specification E12-5 and actual chart sample. P32-1

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster shipment—from stock
- Minimum inventory of parts
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BAILEY METER COMPANY
1047 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

BAILEY METER
Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
RATIO · DENSITY

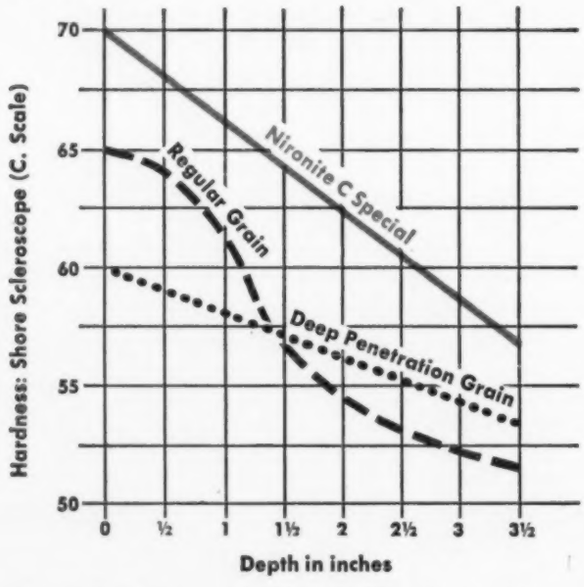
TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

How to pick rolls for bar and billet mills

The crux of the problem—Roughing a pass in a roll for a bar mill.



Generalized curves show how hardness decreases below the surface of three types of roll.

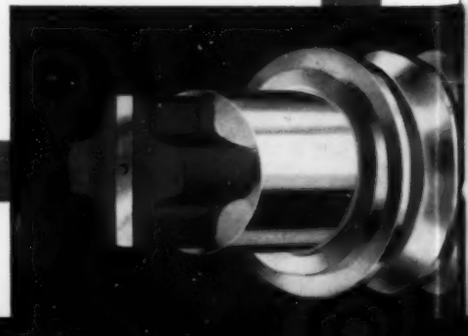
Like all rolls, those for the intermediate and finishing stands of bar and billet mills must possess the best possible balance of strength-vs.-hardness. However, they cannot be chosen on this basis alone.

The problem is complicated by the shape and depth of the passes. Many rolls must be cast plain because of the size of the passes or because of the roll user's need for plain rolls which may be turned for any section. Hence, large amounts of metal must be removed during turning.

As a result the metallurgist strives for two prime objectives in rolls for these applications. They are (1) the greatest possible depth of hardness and (2) fine grain structure to provide smoothness of work surface at the bottom of the passes.

A practical solution—The Nironite C Special roll is the answer that Mack-Hemp has developed to meet this problem. In this indefinite chill nickel-chromium alloy iron roll, depth of penetration is achieved by careful control of the carbon content. This results in deep penetration as well as less and finer graphite in the solidified iron. Hardness decreases very gradually as distance from the surface increases (see graph at left). Thus, this manipulation of carbon provides excellent wear resistance even at the bottom of deep passes. And the low graphite content which is assured by this special composition provides excellent surface condition at depths well below the original surface.

Nironite C Special rolls are only one example of the way Mack-Hemp can combine metallurgical research with nearly five generations' experience in the "art" of roll making to improve the performance of modern rolling mills. For help with your special rolling problem, write us today.



MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

DIVISION OF **E. W. BLISS COMPANY**

Equipment News...

FIXTURE HANGER

▲ The Pyle-National Co. has developed new threaded cover fixture hangers for suspending explosion-proof or dust-tight pendent lighting fixtures.

Known as pylets, they are furnished with a set screw in the hub which locks the stem to prevent turning.

The pylets are regularly furnished without mounting feet but can be supplied with a mounting strap when specified. Connection blocks, which are ordered separately, provide a convenient means for connecting line and fixture wires without splices in VTH series pylets.

The fixture may be completely assembled and wired on a bench ready for attaching to the hangers and connection block. The connection block is designed to fit them without fastening screws. The fixture can be quickly and easily removed for maintenance or replacement after disconnecting the wires at the terminal screws. The units have a cadmium plated ferrous alloy body with aluminum alloy cover.

STEAM GUN

▲ Designed for steam cleaning efficiency, cool handling, and easy operation is a steam cleaning gun recently introduced by Oakite Products, Inc.

An important feature of this new solution-lifting steam gun is the way in which the cleaning solution is used to protect the operator from the heat of the steam. Where other similar steam cleaning devices have had separate tubes for solution and steam, this gun uses a tube within a tube—steam passing through the insulated interior tube, solution through the exterior. The steam loses none of its heat, but the cleaning solution reduces the external temperature of the gun.

The solution is automatically drawn into the nozzle of the gun by the partial vacuum created by the steam passing through.

The new gun has a sealed rotary joint which makes it possible to rotate the nozzle without twisting or wrestling with heavy solution or steam hose. While the forward end of the gun revolves to clean at any desired angle, the handle and hose connections remain stationary. Operator fatigue is further reduced by designing the gun so the thrust of the steam is taken up between the handles.

Precision made, the gun has a cast aluminum spade-type rear handle, cast brass valves, stainless steel outer and inner tubes and nozzle, and an oil-resistant forward rubber grip. It weighs 6¾ lb in its 3½ ft length, and slightly more in the 5 ft size. Maintenance of the gun is simple—there are no moving parts except the brass valves and the sealed rotary joint. Because solution goes through the tube at a comparatively low temperature, there is little danger of clogging or scaling up. The nozzle is protected from rough treatment by an added stainless steel tip.

INSTALLS NEW 15-TON ANNEALING FURNACES

This is one of six new elevator-type electric annealing furnaces recently placed in operation at Allis-Chalmers Pittsburgh Works for heat-treating semi-processed transformer core steel. Each of the 15-ton, 360-kw furnaces heats the steel for several hours around 2000 F temperature in a controlled atmosphere of hydrogen. Coils of core steel are placed in retorts on cars and hoisted into the furnaces. Heating and soaking operations are all instrument-controlled. Upon completion of the treating cycle in the controlled atmosphere, the loaded car is removed and a hood is placed over the steel for careful cooling. Unit is shown with its electric control panel, 60-kw saturable core reactors and 230-volt, 900-amp magnetic contactor, along with the 750-kva, Allis-Chalmers dry-type transformer with air interrupter switch. Each transformer supplies power to two furnaces.

PRINTER

▲ Developed recently by the Pannier Corp., is a new offset bar and tube printer.

Code numbers, trademarks, specifications, etc., are printed at speeds up to 200 fpm either by variable speed drive or friction driven from conveyed material. It automatically imprints by friction contact and will accommodate sizes from ½ in. to 14

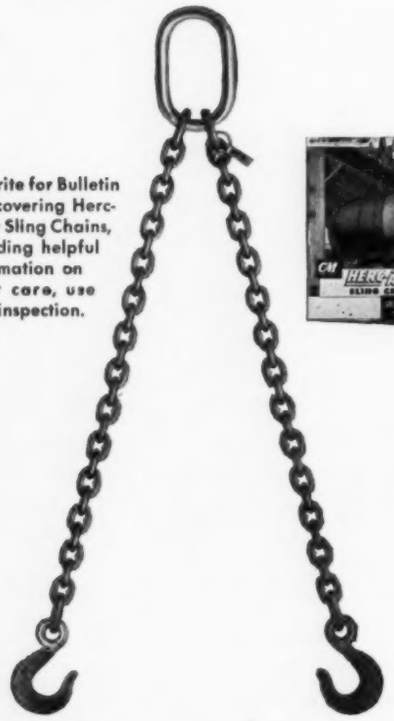
HERC-ALLOY

SLING CHAINS

● Herc-Alloy is the only exact-size alloy chain on the market. This uniformity gives you a lighter and easier-to-handle chain without any sacrifice in working load limit.

● Herc-Alloy, the original alloy steel chain, is available in running lengths as well as in all types and sizes of slings made to customer specifications.

● Write for Bulletin 100 covering Herc-Alloy Sling Chains, including helpful information on their care, use and inspection.



● CM also produces a complete line of chain attachments and welded chain of all types including stainless steel and bronze.

CM
HOISTS AND CHAIN

COLUMBUS McKINNON
CHAIN CORP.
Tonawanda, New York
Regional Offices: NEW YORK • CHICAGO • CLEVELAND
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Herc-Alloy®

in. OD with only one set of guide rolls. Self contained hydraulic height adjustment completely simplifies adjustments to any size.

A feature of this new machine is that setup or change-over time for various sizes, colors, and markings are kept to an absolute minimum by simple adjustments and quickly interchangeable components.

This printer will clearly mark all types of rigid or semi-rigid materials, such as steel, iron, aluminum, nickel, stainless, plastic, wood, rubber (hose), etc.

TV MOUNT

▲ A new remote control pan and tilt mount for industrial television has been announced by Diamond Power Specialty Corp. This new unit can be used on both outdoor and indoor installations.

Rotation is full 360 deg or it can be limited to any arc desired. Tilt is 45 deg above horizontal and 45 deg below—90 deg in all. Complete 360 deg rotation is accomplished in 36 seconds while 90 deg tilt requires 15 seconds.

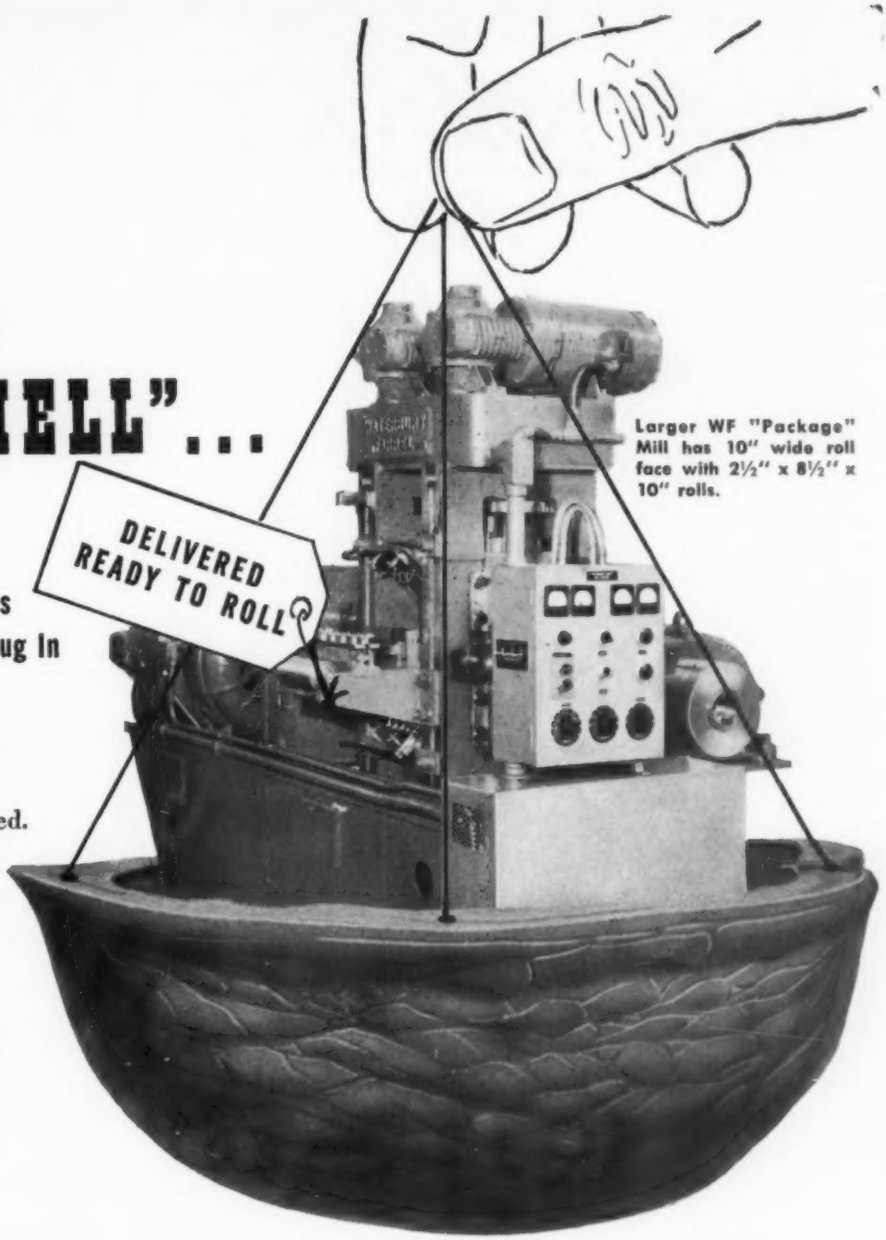
Pan and tilt motions are driven by separate motors individually and remotely controlled from a control panel located at any desired point. The mount is especially useful where it is necessary to have one camera cover a very wide area.

MOTOR

▲ A totally enclosed non-ventilated and totally enclosed fan cooled motor conforming to the dimensional

Waterbury Farrel's
New, ONE-PIECE

STRIP MILL "IN-A-NUTSHELL"...

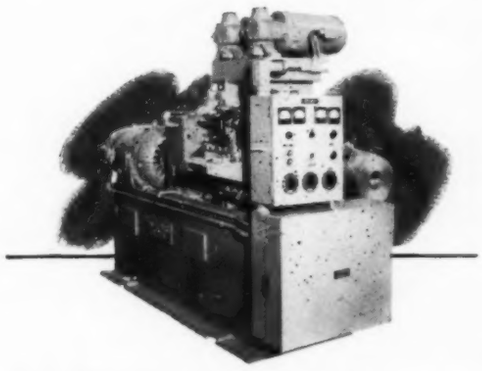


Larger WF "Package" Mill has 10" wide roll face with 2½" x 8½" x 10" rolls.

WF's 4-High "Package" Rolling Mills Are Compact, Low Cost, Ready To Plug In

You can start precision-rolling ferrous or non-ferrous strip as soon as you plug in the electrical connection.

This mill is completely self-contained. Drive, gear case, controls, lubrication system, winder and winder drive are assembled with the mill, itself, into a single, compact unit. When necessary, it can easily be moved in one piece to a new location.



Smaller WF "Package" Mill has 6" wide roll face with 1⅝" x 6½" x 6" rolls.

Some Construction Features: Mill frame of unit welded plate steel gives maximum strength and rigidity . . . assures greater accuracy and lasting alignment . . . alloy steel work rolls mounted in needle bearings . . . alloy steel back-up rolls drilled for water cooling, mounted in double row Timken bearings with tapered sleeve . . . independent power screwdowns . . . long and short roll necks and staggered couplings permit heavier construction for maximum torque capacities . . . lucite cover on welded steel gear case facilitates inspection . . . variable speed tension control drive, using AC power, cuts control cost and permits compact panel.

Contact Waterbury Farrel for complete details. No obligation.

WATERBURY FARREL FOUNDRY & MACHINE CO. • WATERBURY, CONN.

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WATERBURY FOUNDED 1851 FARREL

WF-17A

DREVER *Salt Bath*

for CONTINUOUSLY DESCALING STAINLESS STRIP

Equipment shown descales 18,700 lbs/hour cold reduced stainless strip 62" wide x .018" to .095" gauge. Maximum operating temperature of bath—960°F

The above 35'-0" long Drever Continuous Descaling Bath will descale 18,700 lbs/hour when strip enters bath at bath temperature. Entering strip temperature is controlled by regulation of quenching temperature after strip is discharged from a catenary annealing furnace.

Drever descaling baths are heated by gas-fired immersion tubes with proportioning automatic temperature control.

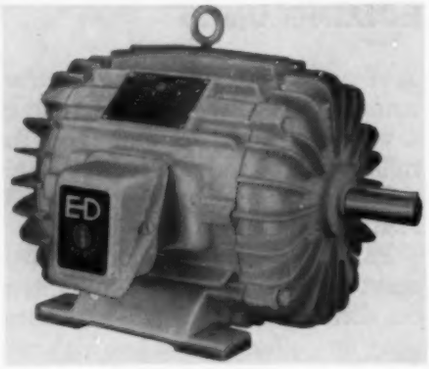
Other baths are supplied for continuous or batch operation for strip, plate, wire, tubing and other ferrous or non-ferrous products.

Write for full information...

DREVER COMPANY

RED LION RD. & PHILMONT AVE. BETHAYRES, PA.

standards recently adopted by NEMA has been placed in production by General Dynamics Corp. Motors have been designed more compactly than previous NEMA design, utilizing less space and larger hp output. The complete housing and end-brackets are constructed of solid cast iron ribbed frame.



The new motor designated as type "H" is designed for operation where non-combustible dust and moisture are prevalent. Motors are now in production on the 182, 184, 213 and 215 frames. Larger ratings will be available in the rerated frame sizes by the latter part of 1955.

Previous design NEMA frames 203 through 505 totally enclosed, fan cooled, are still being produced.

FURNACE

▲ Morgan Engineering Co. has announced operation of a modern stress-relieving furnace capable of handling a 50 ft long load and equipped with the newest heat and combustion controls.

The 52 x 20 x 15 ft inside chamber relieves stresses built up in the welding process. It makes metal easier to machine, more ductile and facilitates shearing.

The furnace can raise the temperature of a 250,000 lb load 200 F per hour up to a maximum of 1750 F. The car, which takes the load into and out of the furnace, is equipped with 40 wheels and is built of heavy structural members. The car is powered by a link chain puller.

The furnace has 48 dual fuel burners equally divided between top and bottom and are fired directly under the suspended arch at the top of the

ENTERPRISE
ROLLER CONVEYORS
ARE MODERN INDUSTRY'S
ANSWER TO CONVEYING PROBLEMS

24 IN. "V" ROLL PIPE
CONVEYOR (DRIVEN UNIT)

These rugged individual conveyor units replace many conventional run-out tables and eliminate the need for mitre gearing, long shafting and interconnecting structure. Standard roll designs include V-Rolls, Flat Rolls, Tapered Rolls, Serrated Rolls and Water Cooled Rolls for furnace applications. Various face widths are available. Idler rolls can be furnished for installation between driven units.

For complete detailed information write for Bulletin 501

ESTABLISHED 1870
THE ENTERPRISE COMPANY
MACHINERY BUILDERS & ENGINEERS
SUBSIDIARY OF WM. K. STAMETS COMPANY · PITTSBURGH
COLUMBIANA 1, OHIO · U. S. A.

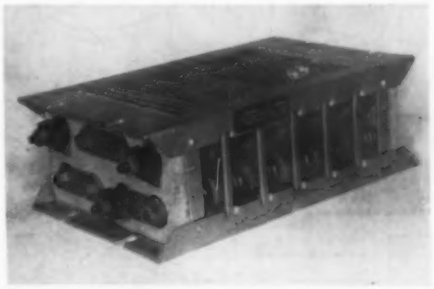
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co. 3100 Prospect Ave.

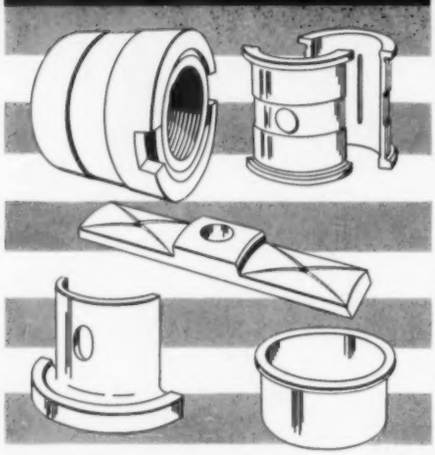
Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

GUYAN MACHINERY COMPANY
LOGAN, W. VA.

FLOOD CITY
for the best
BRONZE
PARTS



Flood City Bronze Parts are best . . . best fitting . . . best wearing . . . all expertly machined from the best grade of hard, wear-resistant bronze or to your particular specification bronze.

For years Flood City has furnished quality bronze parts at a savings in metal weight and machining costs to a variety of industries.

We welcome your inquiries concerning quotations and delivery on your bronze parts needs. Our reply will be prompt —and there is no obligation.

Be sure of the BEST— specify FLOOD CITY.

SERVICE FC FIRST

FLOOD CITY
BRASS & ELECTRIC CO.
JOHNSTOWN, PA.
PHONE: Johnstown 8-1281

furnace and over the car at the bottom. The burners can be fired with either fuel oil or natural gas. The 48 burners have a total input capacity of 33,000,000 Btu per hour. Combustion air is provided by a 50 hp blower.

The burners are equally divided into three zones of temperature control. Each zone is controlled by a circular chart, electronic potentiometer, the control point of which is set automatically by a pneumatic time pattern transmitter.

Safety devices such as high limit temperature controls, safety fuel shut-off valves and combustion safeguards insure against overheating and provide automatic shut-offs or bell alarms in case of power or combustion failures.

The furnace walls are 18 in. thick and consist of 2000 deg insulating brick. The walls have an approximate heat loss of 255 Btu per sq ft, and approximate heat storage value of 7300 Btu per sq ft. The furnace door is of the bulkhead type and is designed as an integral part of the car. Sand seals are along both sides and one end of the furnace and car.

GRAPPLE—MAGNET

▲ A new combination grapple and magnet just developed by M. P. McCaffrey, Inc., speeds scrap handling operations.

The grapples are lighter in weight, yet provide two to three times as much pickup capacity as a grapple, magnet, or clamshell bucket alone, using the same crane.

Designed for handling baling material, small loose material, prepared scrap, or for clean-up, the grapple-magnet relays on four keenly pointed tines to achieve improved penetration into all types of scrap metals. These sharp prongs bite deeply into the scrap, holding it firmly while being carried overhead and preventing the load from slipping. The grapple-magnet is designed to fit in an eight ft truck body. The grapples weigh approximately 2300 lb, and the magnet, 1100 lb.

ROLLING UNITS

▲ A new line of high grade performance precision rolling mills, built in a wide range of sizes and types for rolling ferrous and non-ferrous materials, has been announced by the H. J. Ruesch Machine Co.

Part of a recent product improvement program covering straighteners, slitters and rolling mills, the company now offers lines of two high and four high rolling mills. Sizes range from small jewelry type two-high mills to large two-high and four-high mills for high production rolling of materials up to 12 in. wide.

Rugged in design, and engineered for extreme accuracy, they are used for hot and cold rolling of strip, sheet, rod and wire as well as for wire flattening, embossing, and forming.

Accessory and special handling equipment, in addition to many outstanding general construction features, can be supplied to make each installation a complete production unit.

Book Reviews . . .

1955 Book Of ASTM Standards: Part 1—Ferrous Metals, (1834 pages, 6 x 9, cloth cover, $13.50), has just been issued by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Containing 315 standards, Part 1 is 11 per cent larger than the 1952 edition and contains 125 standards that are new or have been revised since the 1954 Supplement was published a year ago. Since 1952, 211 standards are new or have been revised.

"Primary Unit Substation," Publication 201-1955 to 207-1955, a recent NEMA Standard Publication, is now available from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y. This standard contains 51 pp., 8½ x 11-in., paper bound and sells for $3.00. This

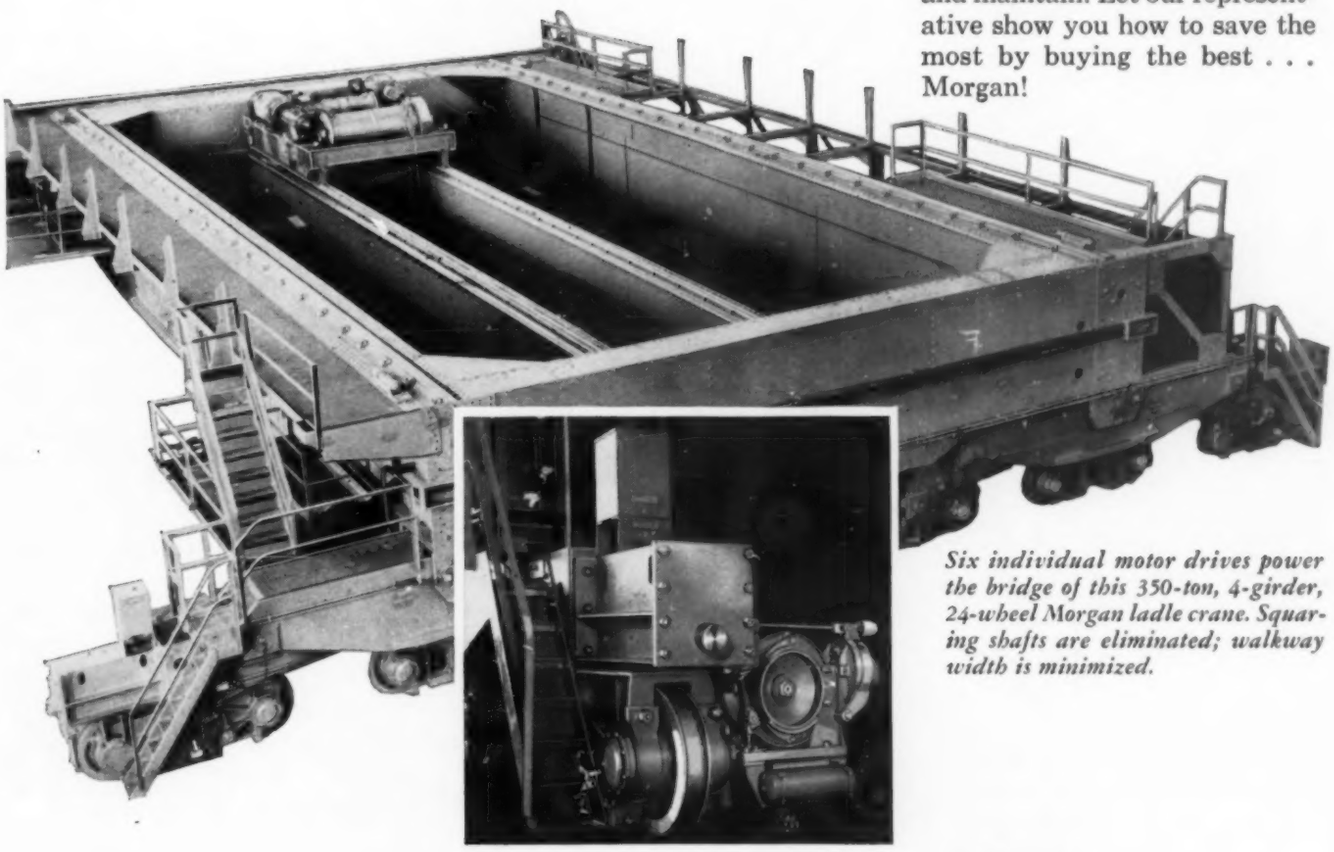
(*Please turn to page 230*)

How Morgan "points the way" to smoother crane operation

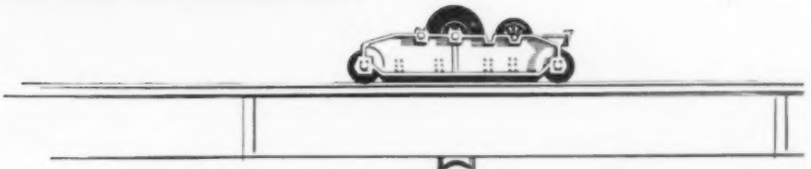
● INDIVIDUAL MOTOR DRIVES were pioneered by The Morgan Engineering Company to improve crane bridge travel . . . to provide smoother operation, to reduce the number of moving parts, to simplify maintenance, to eliminate dead weight of drive shafts, to streamline the crane.

These individual motor drives are another vital link in the chain of features that make Morgan cranes the best in the business.

Performance records prove that advanced design and heavy-duty construction of Morgan cranes make them less costly to operate and maintain. Let our representative show you how to save the most by buying the best . . . Morgan!



Six individual motor drives power the bridge of this 350-ton, 4-girder, 24-wheel Morgan ladle crane. Squaring shafts are eliminated; walkway width is minimized.



THE MORGAN ENGINEERING CO. Alliance, Ohio

The Morgan Engineering Company, founded in 1868, manufactures overhead electric traveling cranes, gantry cranes, charging machines, plate mills, blooming mills, structural mills, shears, saws, and auxiliary equipment.

It Costs No More To Give More—
If You Give The Bonus In Savings Bonds!

If your company is one of the more than 45,000 companies that have the Payroll Savings Plan you *know* what your employees think of Savings Bonds – they spell it out for you every month in their Savings Bond allotments.

If you don't have the Payroll Savings Plan, and are wondering whether your people would like to receive their bonus in Bonds, here are a few significant facts:

—every month, *before they get their pay checks* or *envelopes*—8,500,000 men and women enrolled in the Payroll Savings Plan invest $160,000,000 in U. S. Savings Bonds.

—Payroll Savers hold their Bonds: From May 1, 1951, to September 30, 1955, approximately $18.7 billion E Bonds reached 10-year maturity dates. On September 30, 1955, approximately 70.3% of the matured bonds were retained by their owners under the automatic extension plan. With additional interest earned since maturity dates ($560 million), cash value of the matured bonds held by individuals amounts to approximately $13.7 billion.

—on September 30, 1955, the cash value of Series E and H Bonds—the kind sold only to individuals—totaled 39.7 billion dollars, a new high.

To the Payroll Saver, and to the man who buys his Bonds at a bank (because his company does not provide the Payroll Savings Plan) a One Hundred Dollar Savings Bond looks bigger and better and *is* bigger and better, than a check for $75. *Make this a merrier Christmas for every employee. Give the gift that keeps on giving.*

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

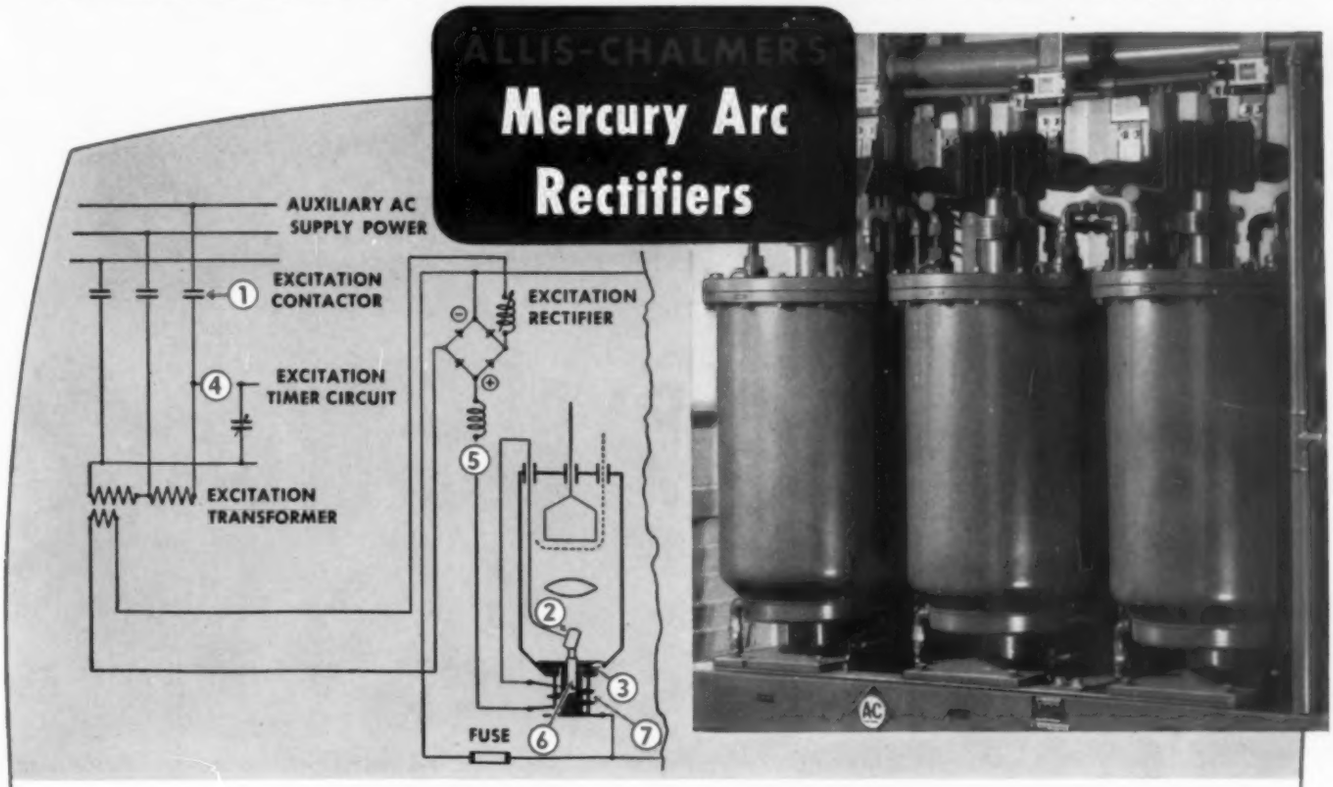
For Reliable Rectifier Operation Get

Continuous Excitation

Allis-Chalmers excitron rectifiers eliminate the need for a pulse-type firing system timed for operation every cycle. Maintenance is easy because of the simplicity of design.

A small dc excitation arc is automatically ignited only once, when the unit is started, and then maintained on the mercury cathode of each rectifier tube. It offers advantages similar to a pilot light. Since it is far easier to maintain an arc than to start it, this feature makes the excitron far less likely to lose excitation during power supply disturbances than other types of rectifiers.

Get all the facts about excitron rectifiers before your next installation. Call the A-C office nearest you or write Allis-Chalmers, Milwaukee 1, Wisconsin.



Supply of DC Provides Key to Continuous Excitation

Direct current supplied from excitation rectifiers is the key to continuous excitation. When the excitation system is energized by means of a contactor (1), positive dc potential appears on the excitation anode (2) of each tube, negative at the cathode (3). A timer (4), through contacts of the excitation failure relay (5), is energized at the same time.

As soon as voltage is applied, current flows from the anode to the cathode through the ignition plunger (6). This current energizes the ignition coil (7) and causes the plunger to be pulled below the mercury surface. As the plunger travels down, an arc is drawn which transfers from the graphite tip of the plunger to the mercury. This current flow keeps the coil energized, maintaining a continuous arc.

If excitation failure should occur while the rectifier is carrying load, the plunger is released, floating upward in the mercury until it makes contact with the anode, then repeating the process above until the arc is re-established.

Re-establishment of the arc as outlined takes less than a second — it does not interfere with normal operation.

ALLIS-CHALMERS

A-4592

The singing child on this year's Christmas Seal is a symbol of hope and faith in the future . . . and a pledge to the present.

The *hope* is the eventual eradication of tuberculosis...the *faith* is in the proved methods of your national, state, and local tuberculosis associations.

The *pledge* is your joining with 13,000,000 of your fellow Americans who this year will buy and use Christmas Seals.

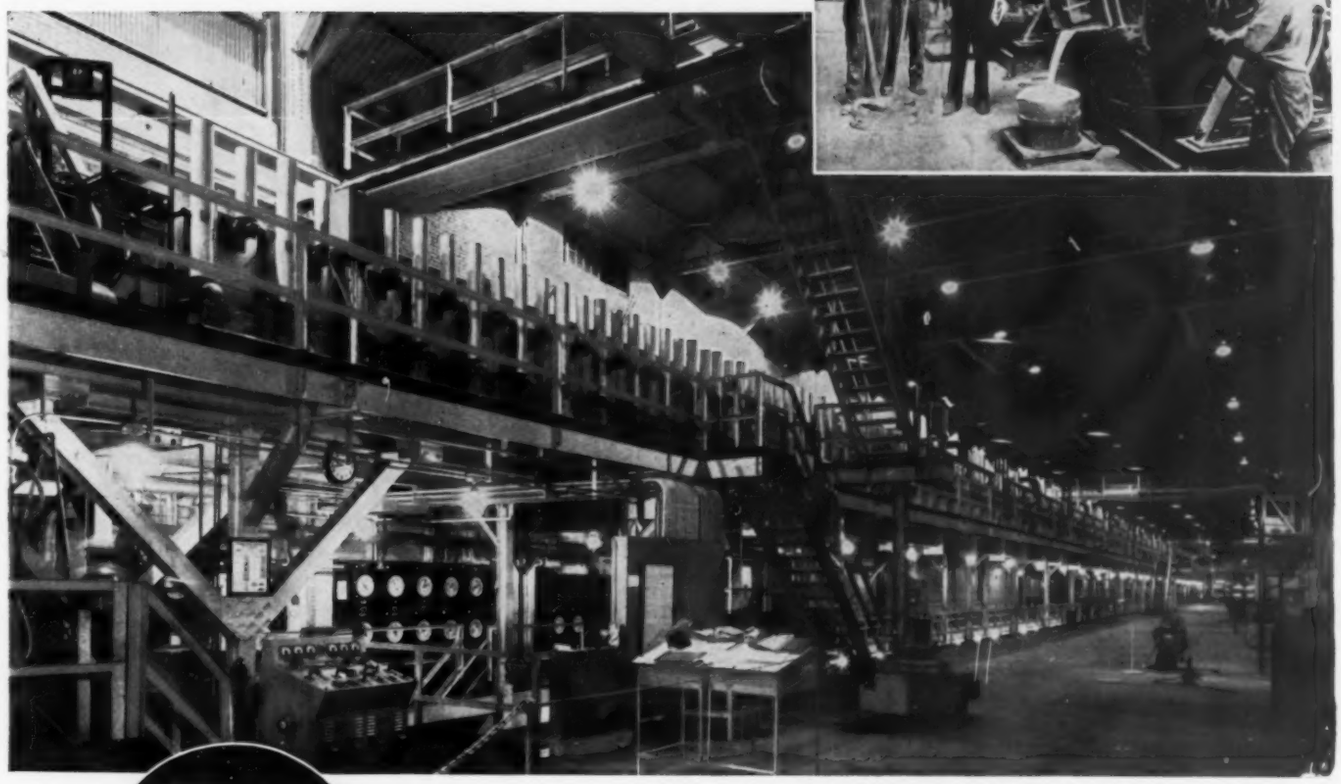
Send your contribution to your tuberculosis association today, please, and join in singing to all humanity, to all the world, "Happy Christmas, Little Friend."

Buy Christmas Seals

Because of the importance of the above message, this space is contributed by

IRON AND STEEL ENGINEER

The first Electric Brass Melting Furnace in America — built by The Electric Furnace Co., Salem, Ohio.



An EF combination electric and gas fired furnace installation in a prominent steel plant producing galvanized strip. This equipment flame cleans, uniformly anneals and galvanizes strip continuously.

Continuing to pioneer

New Developments

in the continuous and batch processing of ferrous and non-ferrous products

From the company's beginning, when the little furnace shown above was "big news"; to the modern, completely automatic, high production strip lines, EF research and development engineers have been making important contributions to furnace design and metal processing techniques.

EF engineers conceived and developed the first automatic and continuous heat treating, quenching and drawing equipment; pioneered the use of endothermic, exothermic and other special atmosphere treatments resulting in closer physical tolerances. Other developments include EF radiant tubes with heat exchangers that assure extremely high combustion efficiency; EF cast alloy electric heating elements; EF roller design — and other facilities that assure uniform temperatures throughout the furnaces, accurate control of heat input, reduced maintenance and high hourly output.

For maximum product uniformity, dependability and efficiency, discuss your heating problems with EF experienced engineers . . it pays.

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GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

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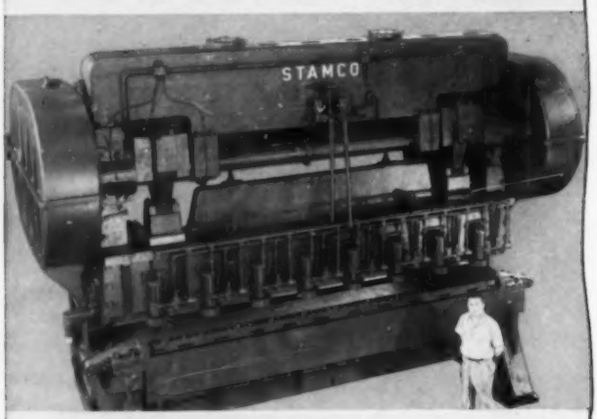
Canadian Associates • CANEFCO, LIMITED • Toronto 1, Canada

For Special Operations in Steel Mills...

STAMCO 80" Side Trimming Unit

STAMCO Coil Box, coil opener and feeding unit



STAMCO 1¼" x 180" plate shear

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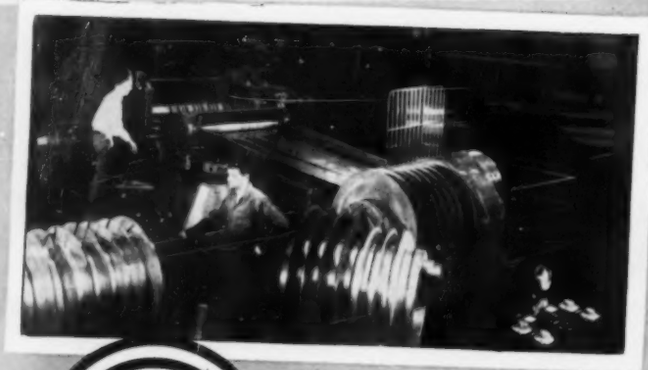
for the equipment you need

For mill or warehouse use on ferrous or non-ferrous material, STAMCO has a model or size to fit your needs—or can make it for you. If you use trimming units, plate shears, slitting units, coil openers or any other special steel mill equipment, it will pay you to write us. No obligation.



STAMCO 48" Slitting & Coiling Line 15000# coil capacity

STAMCO 72" Heavy Gauge Side Trimming and Slitting Unit equipped with a double set of feed and delivery pinch rolls.

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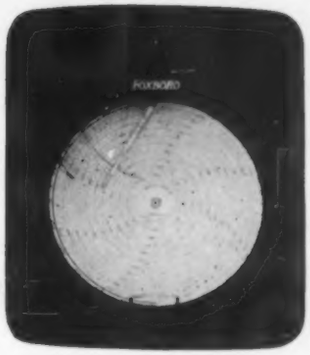
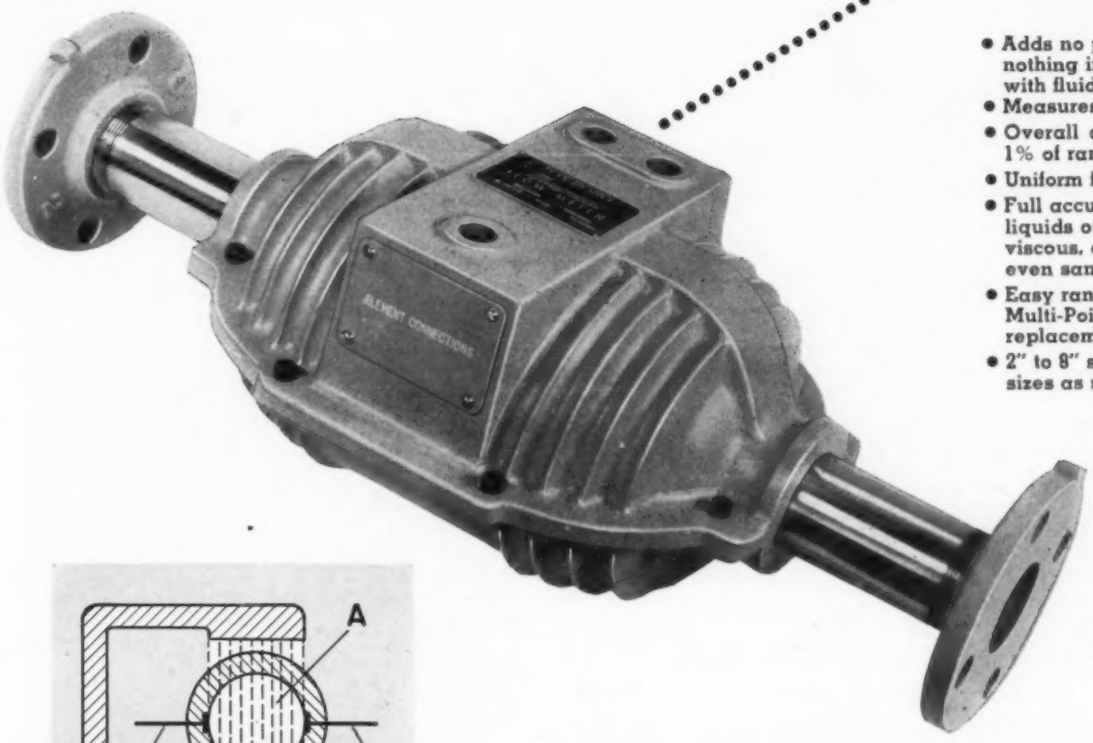
STAMCO, Inc., New Bremen, Ohio

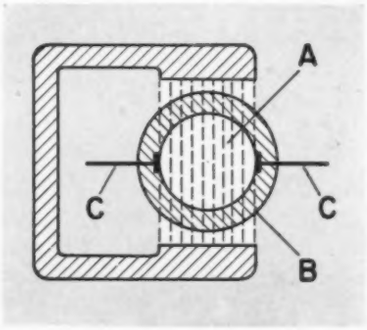
NEW! a flow meter with no flow restrictions!





- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Full accuracy sustained even on liquids other meters can't handle: viscous, corrosive, or pulpy — even sand-water slurries.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 2" to 8" sizes standard — larger sizes as required.

FOXBORO MAGNETIC FLOW METER



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The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

This premium-performance meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by 2-conductor cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul.

Foxboro Magnetic Flow Meters are already in use on such widely different liquids as beer, sand-and-water, rosin size, rock-and-acid slurry, viscose, and highly corrosive liquid detergent. Find out how this precise, troublefree flow meter can help your processing. Write for complete details.

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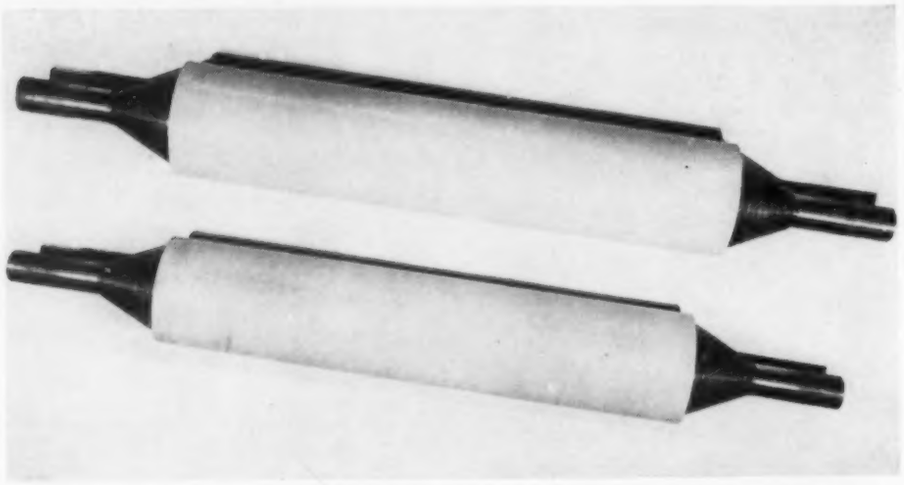

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consistently prove their value in
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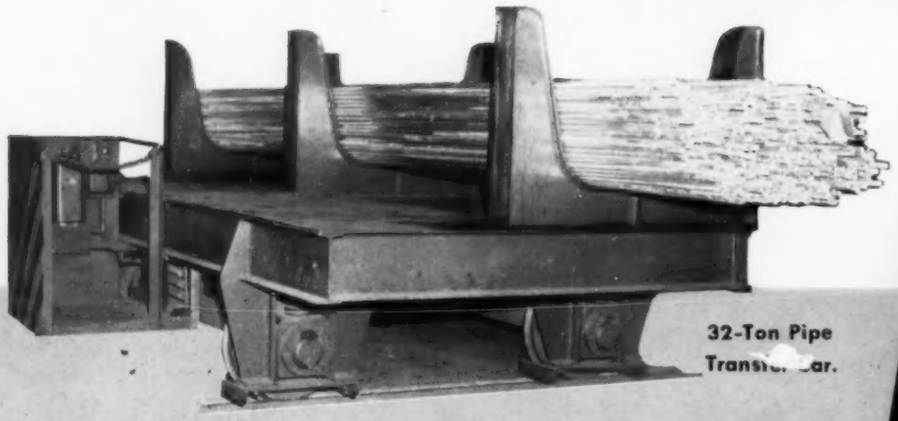

32-Ton Pipe Transfer Car.

- STORAGE BATTERY Walk-Along or Rider-Type
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- CABLE REEL . . . AC
- CABLE REEL . . . DC
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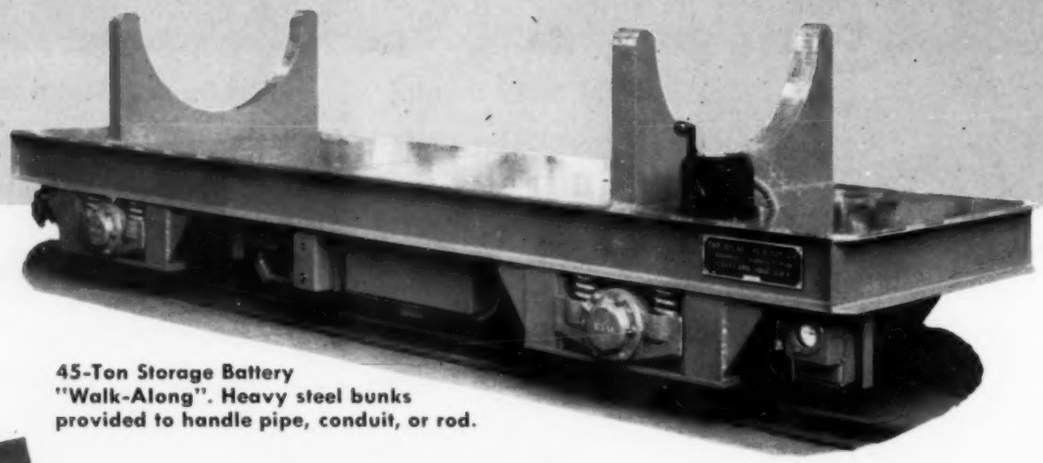
Also remotely controlled cars without trailing cable.

● Atlas Transfers are controlled by one lever. When the lever is released the car stops. This simplicity assures safety so that no assigned operator is necessary.

SAFE because there is only one control lever.

SAFE because the car will move *only* when the operator holds the lever.



45-Ton Storage Battery "Walk-Along". Heavy steel bunks provided to handle pipe, conduit, or rod.

Ask for "Walk-Along" Bulletin 1283 for complete transfer car information.

Manufacturer of Ore Transfer Cars • Scale Cars • Coal Charging Cars • Coke Quenching Cars • Coal and Metal Mining Storage Battery Locomotives.

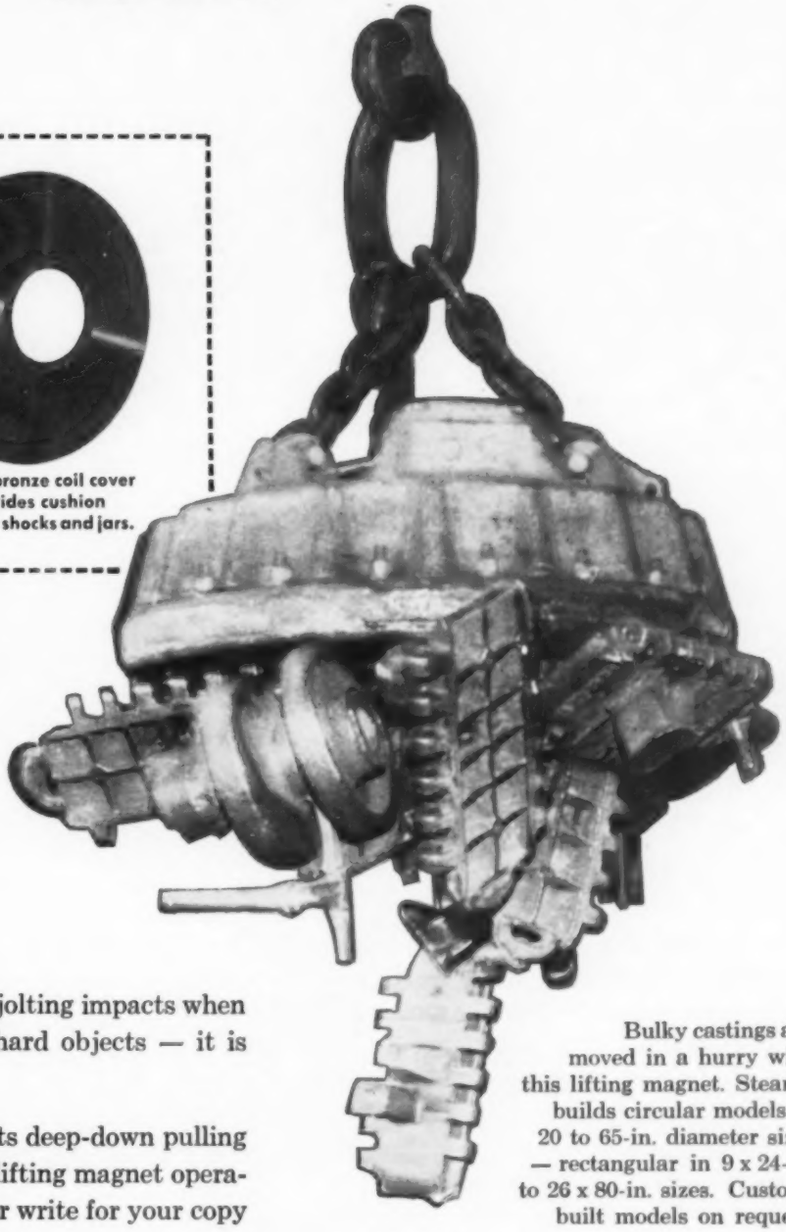
THE ATLAS CAR & MANUFACTURING CO.

1100 IVANHOE ROAD **CLEVELAND 10, OHIO**

Exclusive Built-in Shock Absorber

PROTECTS DEEP-DOWN PULLING POWER

Heavy bronze coil cover provides cushion against shocks and jars.



Bulky castings are moved in a hurry with this lifting magnet. Stearns builds circular models in 20 to 65-in. diameter sizes — rectangular in 9 x 24-in. to 26 x 80-in. sizes. Custom-built models on request.

Powerful, deep-field Stearns lifting magnets are built with an extra wall of protection against shocks and jars. In addition to the regular coil shield of chrome-nickel steel, Stearns adds a heavy bronze coil cover — an *exclusive* feature.

This shock-absorbing cover provides a double advantage—it is both ductile and tough. It not only absorbs jolting impacts when the magnet is banged against sharp, hard objects — it is strongly resistant to damage.

Find out *all* the ways Stearns protects deep-down pulling power — gives you long life, profitable lifting magnet operation. See your Stearns representative or write for your copy of Bulletin 35-C.

1078

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STEARNS MAGNETS

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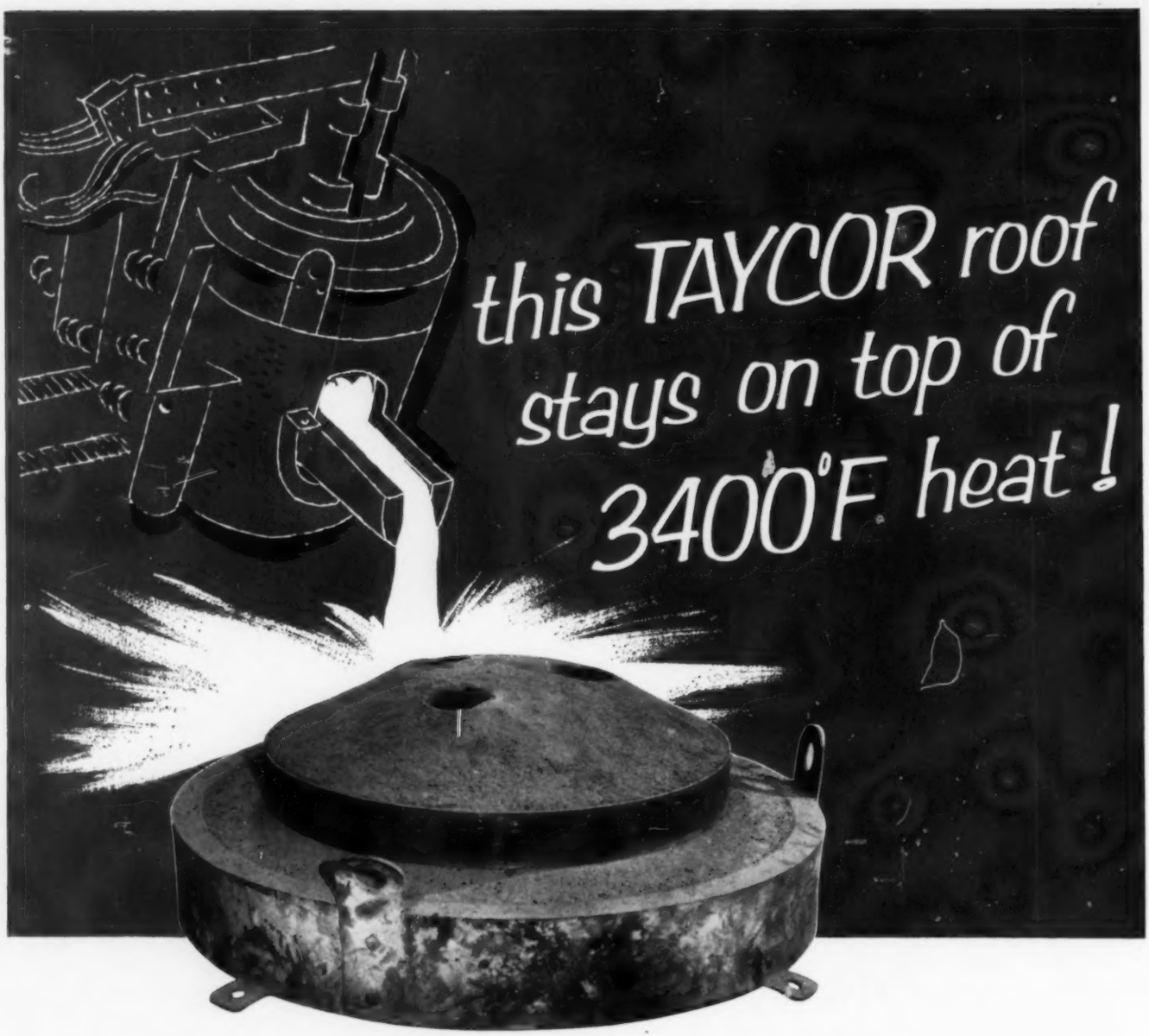

This monolithic roof of TAYCOR Ramming Mix is for a 1000-lb. basic direct arc furnace used to melt a variety of heat-resistant alloys. Furnace operates 16 hours daily at temperatures as high as 3400° F. Extensive tests have been conducted to improve roof life for this severe application. The result of these tests proved TAYCOR Ramming Mix lasted *two to three times longer* than any other refractory. TAYCOR roof life varies from a low of 200 heats to a 900-heat record high, depending upon the alloy being melted.

TAYCOR is our trade name for Corundum-base super-refractory brick, special shapes, cements, patches and ramming mixes. The outstanding properties of TAYCOR are exceptional refractoriness, high hot load strength, superior resistance to mechanical abrasion and attack from iron oxide.

These properties make TAYCOR the ideal refractory for hearths, piers, slot bottoms, front walls, skid rails of forge, heating and heat-treating furnaces . . . for small basic direct arc furnaces operated at higher-than-normal temperatures, requiring long heats . . . for linings of indirect arc furnaces . . . for rammed crucibles of high-frequency induction furnaces. Put TAYCOR to the test in your furnaces. For further information, write direct or call in a Taylor field engineer.

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BOOK REVIEWS

(*Continued from page 216*)

publication contains standard equipments and additional and alternate standard equipments for the following: articulated primary unit substations—radial, primary-network, spot-network, low voltage selective and duplex types; integral primary unit substations; and highway-type mobile primary unit substations.

"Problems and Control of Air-Pollution," edited by Frederick S. Mallette under the sponsorship of The American Society of Mechanical Engineers, was recently published. The book has been written to include the newest and most authoritative material available, particularly in its chapters on the treatment and recovery of sulphur dioxide which is widely recognized as one of the most formidable challenges to effective air-pollution control. It is of interest and value to all concerned with reducing or eliminating air contamination, including civic groups, municipal officials and those concerned with the medical, biological and meteorological aspects of air-pollution. This book, containing 272 pp., 6 x 9-in., cloth bound, selling for $7.50, is published by Reinhold Publishing Corp., 430 Park Avenue, New York 22, N.Y.

"A List of Gas Equipment for Industrial Uses," 1955 edition, price $1.00 has just been issued by the Industrial Gas Equipment Division of the Gas Appliance Manufacturers Association, 60 E. 42nd St., New York 17, N. Y. This fourth edition is divided into three sections. The first section lists the names and addresses of the various manufacturers of industrial gas equipment and the particular products of each company. The second section lists alphabetically gas equipment and accessories followed by the names of the companies that makes each one of these products. The third section lists the various trade names under which products are sold and the company that makes them.

"Magnetic Materials in the Electrical Industry," by P. R. Bardell has been recently published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Book contains 288 pp, 5½ x 8½-in., cloth bound and sells for $10. This book covers production, measurement and application of certain classes of magnetic materials. This publication is directed primarily to students, teachers, and others engaged in research or manufacture in any of the many industries concerned with magnetism and magnetic materials.

"Metallurgical Progress — 2," reprinted from Iron and Steel of England, under authorships of Drs. J. M. McLeod, D. D. Howat, and H. B. Bell, has just been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. This volume contains the essence of 30 years' research work in the preparation of ores, electric steel production and non-metallic inclusions reviewed by the above three authors respectively. Here is described the existing work to date and a discussion of its relative value to industry is given.

"Electro-Magnetic Machines," by R. Langlois-Berthelot has just been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 535 pp., 5½ x 7½-in., cloth bound, price $15. This book, first written and published in France, went over so well that it was felt worthwhile to publish this edition in English. This book should establish itself as a standard work on the subject of electro-magnetic machines. It is unique in its manner of presentation in that it relates various kinds of electrical machines to each other, and treats them as a family. Emphasis is on fundamental principles rather than practice.

"Constructional Steelwork," by Oscar Faber, has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. It contains 368 pp., 5¼ x 8½-in., cloth bound, and sells for $12. Here is presented a clear and thorough explanation of the principles underlying the design and construction of steel frame buildings and other steel structures. From simple beginnings, the reader is led step by step to more complex aspects such as the design of frames with end restraint and monolithic welded frames. The use of complicated mathematics has been avoided, and drawings are used profusely.

"Developing Your Executive Skills," by Auren Uris has just been published by McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, N. Y. It contains 270 pp., 5 x 8-in., cloth bound and sells for $4.50. Based on the idea of sharpening and improving your executive skills, it discusses with interest each natural executive skill in detail and tells how they may be used to one's best advantage. The chapters cover the various aspects of the executive's role today, including how to be a good administrator, decision making, long-range planning, executive problem solving, communication, working with subordinates, correspondence, interviewing, sharpening mental focus and memory. It has self analysis tests and quizzes and a personal efficiency guide. This book will serve as a benefit to all levels of business people from presidents and vice presidents down the line to junior executives, department managers, supervisors or anyone with a degree of authority and responsibility.

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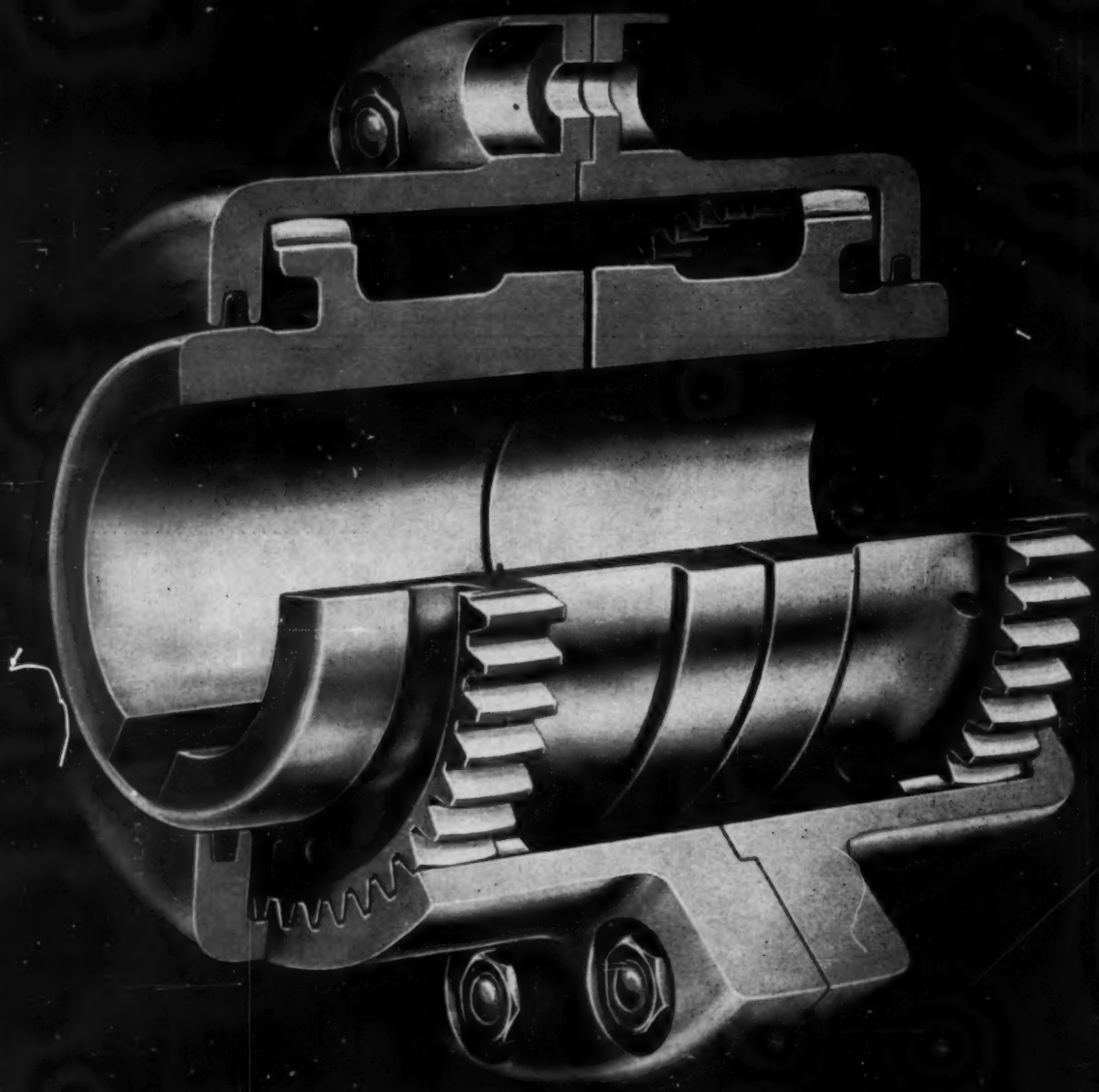

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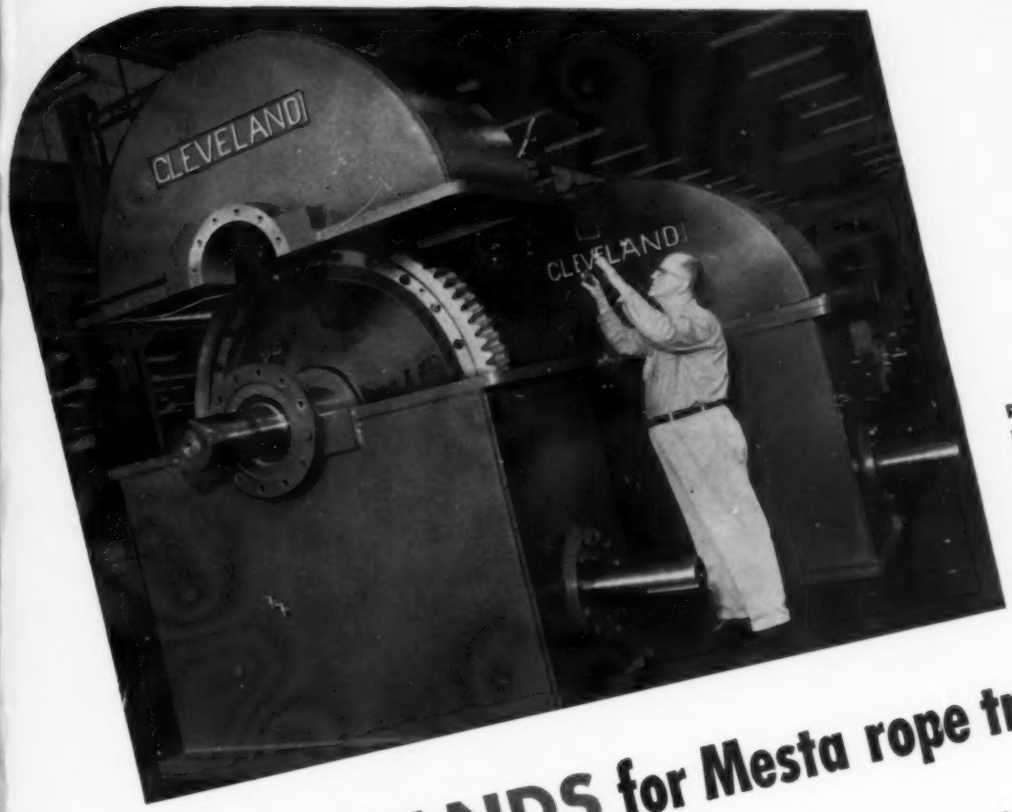
POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.



Rated at 139 HP, Class 1 service, at 450 RPM—housings for these king-size Clevelands are of welded steel construction with gear shafts extending on both sides. Clevelands can be built to fit any requirement, large or small.

Giant CLEVELANDS for Mesta rope transfer drives

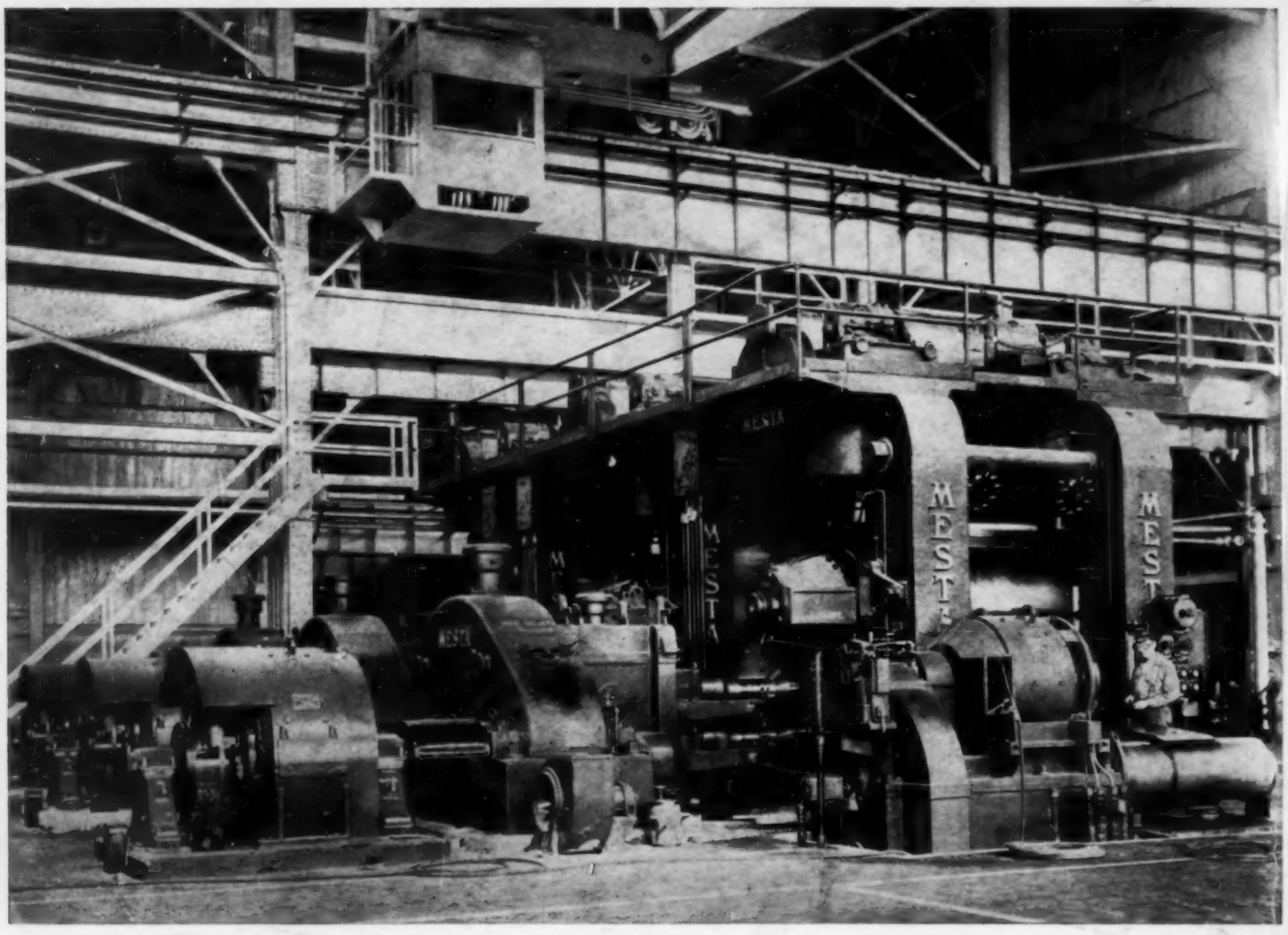
CLEVELAND Worm Gear Speed Reducers can be king-size, too. Here are two of six units, with 36" center distance built recently for the Mesta Machine Company of Pittsburgh, Pennsylvania. These giant drives are being placed in service at a steel company as rope transfer drives in the beam mill.

Mesta continues to choose Clevelands because they know from long experience that they perform well under heavy duty steel mill service. They transmit power uniformly and smoothly. Unvarying efficiency stems from Cleveland's case-hardened steel worms which run in perfect mesh with nickel-bronze gears. And, this is a combination that actually improves with use—proven by record in hundreds of instances.

Learn more about the advantages Clevelands have to offer—write today for free Catalog 400. The Cleveland Worm and Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers



Polar additives assure better gear and bearing protection

ONE of the "musts" for an effective enclosed-gear lubricant is ability to cling to metal under adverse operating conditions. *Texaco Meropa Lubricant* contains polar additives which cause it to adhere tenaciously to gears under *all* conditions—even when immersed in water.

But this is only one of the reasons for the superiority of *Texaco Meropa Lubricant*. Some others—

1) High Load carrying capacity: The extreme pressure properties of *Texaco Meropa Lubricant* toughen its lubricating film so that it withstands shocks and heavy duty steady loads far in excess of manufacturers' requirements for gears and bearings. Moreover, these EP properties outlast those of other lubricants.

2) Resistance to thickening and foaming: *Texaco Meropa Lubricant* effectively resists the heat-induced thickening that is normal with all lubricants. It will not foam.

3) Great stability: *Texaco Meropa Lubricant* will not separate in use, storage or centrifuging.

4) Non-corrosive: *Texaco Meropa Lubricant* will not corrode any of the metals used in gears and bearings.

Let a Texaco Lubrication Engineer give you full information. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write:

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The Texas Company, 135 East 42nd Street, New York 17, N. Y.

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FOR STEEL MILL GEAR DRIVES

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